# Two-Channel TransPort™ Model 2PT868 Portable Flowmeter

User's Manual

# Two-Channel TransPort™
# Model 2PT868 Portable Flowmeter

*User's Manual* *910-142B*

**PANAMETRICS, INC.**

# Warranty

The Two-Channel TransPort<sup>TM</sup> Model 2PT868 Portable Flowmeter is guaranteed by PANAMETRICS to be free from defects in materials and workmanship for a period of one year from the date of shipment to the original customer, provided that the equipment has been installed and used in the manner described in this User's Manual. Fuses and transducer cables are not included in this warranty. Repair or replacement, at PANAMETRICS' option, will be made without charge at the plant during the warranty period.

# Return/Repair Policy

If problems develop, do the following:

**1.** Notify PANAMETRICS, giving full details of the problem. Be sure to include the model and serial numbers of your flowmeter. PANAMETRICS will then give you a Return Authorization Number and/or shipping instructions, depending on the problem.

**2.** If PANAMETRICS instructs you to send your flowmeter back to the factory, please send it prepaid to the authorized repair station as described in the shipping instructions.

The PANAMETRICS Two-Channel TransPort<sup>TM</sup> Model 2PT868 warranty is limited to the conditions stated above. PANAMETRICS will not be liable for anything beyond this.

**Note:** *All equipment sent back to the factory must be accompanied by a Return Authorization Number. To get a Return Authorization Number, contact the Customer Service Department.*

## FCC Compliance

**!WARNING!**
**THIS EQUIPMENT GENERATES, USES, AND**
**CAN RADIATE RADIO FREQUENCY ENERGY,**
**AND, IF NOT INSTALLED AND USED IN**
**ACCORDANCE WITH THIS USER'S MANUAL,**
**MAY CAUSE INTERFERENCE TO RADIO AND**
**OTHER COMMUNICATION DEVICES. CONSULT**
**PANAMETRICS FOR FURTHER DETAILS.**

## Purpose of This Manual

The Panametrics *Two-Channel TransPort^{TM} Model 2PT868 Portable Flowmeter User's Manual* (910-142) explains how to make the necessary connections, operate, and maintain the Model 2PT868. Should field service that is beyond the scope of this manual become necessary, contact the Panametrics office nearest you. A list of Panametrics offices is on the back page.

## Intended Audience

This manual is intended for people who install, use, and maintain instrumentation devices. This manual presumes the audience has some general familiarity with analytical devices as used in their application; however, no knowledge of Panametrics systems is required.

This manual is a general reference for personnel who have overall responsibility for using and maintaining process monitoring devices.

## Manual Organization

This manual consists of 11 sections, 9 appendices, a Table of Contents and an index.

# How to Use This Manual

Since this manual is written for a multi-user audience, each section can be used separately. Sections appear in the order they are to be read. In addition, the subsections are also organized in the order they should be used.

This manual is constructed so that a first time user does not need to have any familiarity with the Model 2PT868. Additional or less frequently used information is included in the Appendices and is referenced throughout this manual.

# Related Documentation

Panametrics will provide detailed drawings and schematics for special purposes upon request.

# Typographical Conventions

Conventions used throughout this manual are listed below:

Characters enclosed in brackets, such as [ENT], represent a key on the keypad. Menu keys are specifically defined as such.

*Double bar and italic text is used to guide you in the use of the manual. Text between the bars refers to additional information or special instructions.*

**Note:** *This message indicates additional information.*

**IMPORTANT:** *This message contains information to help the user avoid possible problems.*

**Caution!**
This message indicates that damage
could occur to equipment.

**!WARNING!**
**THIS MESSAGE INDICATES DANGER AND THE**
**POSSIBILITY OF PERSONAL INJURY.**

## Revision Information

This manual may require updating because of corrections or changes in the product. Publication dates are on the top right hand corner of the title page of the manual. Changes are indicated by a different date on the changed page.

## Commenting on This Manual

We welcome your comments and suggestions for improving the quality of our manuals. You can comment four ways:

- Fill out the prepaid postage response card in the front pocket of this manual.

- Send comments to Panametrics, PCI Division, Technical Publications Department, 221 Crescent Street, Waltham, Massachusetts 02453. Attention: Comments.

- Fax us at 781-642-1349, attention Technical Publications Department.

- Call us at 1-800-833-9438 (within the U.S.A.). Ask for the Technical Publications Department. For calls outside the U.S.A., call (781) 899-2719.

## Questions

If you have any questions, call our toll free number: 1-800-833-9438 in the U.S.A. and ask for a flowmeter applications engineer. For calls outside the U.S.A., call (781) 899-2719.

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# Chapter 1

# Features and Capabilities

The Two-Channel TransPort™ Model 2PT868 is a transit-time flowmeter with all the features of a full-size flowmeter, plus features that were never before available.

This section describes the TransPort features, its general system, and theory of operation.

## Overview

The Two-Channel TransPort measures the flow rate of acoustically conductive single-phase fluids that may have a second phase present. This includes most clean liquids, sewage, some slurries, some oil/water mixtures, and liquids with a small percentage of entrained gas bubbles. The flowmeter provides two linear (4-20 mA or 0-20 mA) analog outputs of flow velocities or volumetric flow rate of these fluids, measuring velocities from ±0.03 to ±12 m/s (±0.1 to ±40 ft/s).

The TransPort's two channels allow it to function like two flowmeters. The TransPort can measure flow in two pipes at one time, two measurement points in the same pipe, or it can average two paths at a single measurement point for increased accuracy. The Two-Channel Transport uses two sets of transducers, one set for each channel, to make flow measurements.

# Overview (cont.)

The Two-Channel TransPort also provides two 4 to 20-mA analog inputs in order to connect temperature transmitters to measure the energy flow rate of liquids. Energy flow rate may be calculated for water, glycol, and water/glycol mixtures. If energy is not being measured, the inputs can be configured and logged as generic parameters.

The TransPort has the ability to store site data for up to 10 sites into files that can be accessed at a later time. The TransPort has a menu-driven user program that asks you all the necessary setup questions for a particular site. Once you complete answering the necessary questions, you simply save the information into a file.

The TransPort stores these files and other data in non-volatile memory even if power is off. The flowmeter itself runs off of a rechargeable battery (for 6 to 8 hours) or line power.

This small lightweight flowmeter displays measurements in both numeric and graphical form on a 64 x 128 pixel screen. The TransPort also has the capability of logging over 40,000 flow data points internally.

The TransPort can transmit or print logged data, as well as real-time data and other stored data, using the RS232 communications port.

To assist you, the TransPort is fully equipped with on-line help, which is accessible at any time by simply pressing the Help key. The TransPort also has internal diagnostic and troubleshooting features to help isolate and remedy common flowcell and transducer problems.

The TransPort operates with all standard Panametrics transducers — wetted, clamp-on, hybrids (Pan-Adapta® plug), and buffered styles, as well as with all standard Panametrics flowcells: axial path, zigzag, tilted diameter, and midradius.The TransPort also has a built-in ultrasonic thickness gage to determine the pipe wall thickness when used with the optional thickness transducer.

# System Description

The Two-Channel TransPort is one part of the flowmeter system. The flowmeter system consists of two essential subsystems: the flowcell and the electronics package.

## The Flowcell

The flowcell is that part of the system where interrogation of the flow by ultrasonic pulses takes place. The flowcell consists of the flowcell piping and the transducers.

**A.** FLOWCELL PIPING — The flowcell can either be created in the existing piping (for example, by inserting wetted transducers into the pipe, or clamping non-wetted transducers onto the pipe), or inserted as a substitute pipe section (spoolpiece). The flowcell must provide mechanical support for the transducers and assure stable fluid conditions for accurate flow measurement.

**B.** TRANSDUCERS — The transducers convert electrical energy into ultrasonic pulses when in a transmit cycle, and convert the ultrasonic pulses back to electrical energy when in a receive cycle. In other words, they act like loudspeakers when transmitting the signal and microphones when receiving it. In the TransPort system, each transducer acts as both a receiver and transmitter since a series of ultrasonic pulses are alternately sent upstream and then downstream through the flowcell.

## Electronics Package

The electronics package consists of circuits that generate, receive, and measure the travel time of the ultrasonic pulses. It also contains a microcomputer that controls operation and calculates flow measurements parameters. Specific circuits function as follows:

**A.** TRANSMIT SIGNAL GENERATOR - The transmit signal generator, under control of the microcomputer and timing circuit, synthesizes the signal that drives the transmitter.

**B.** TRANSMITTER — The transmitter amplifies the signals from the transmit signal generator to a signal that drives the transmit transducer.

**C.** RECEIVER — The receiver amplifies the received signals to a level suitable for the Data Acquisition circuitry.

**D.** DATA ACQUISITION — The Data Acquisition circuitry digitizes the received signal and stores it in a buffer for processing by the microcomputer.

**E.** TIMING CIRCUIT - The timing circuit generates the transmitter frequency, receive window, controls the Data Acquisition circuit and the direction of the transmission.

**F.** MICROCOMPUTER - The microcomputer controls the TransPort flowmeter's operation and calculates flow measurements derived from the transmitted and digitized received signals. Also, the microcomputer continually checks for faults and allows the use of built-in diagnostics for troubleshooting.

**G.** INPUT/OUTPUT - The input/output circuitry allows the flowmeter to indicate the measured flow with the 4 to 20 mA or 0 to 20 mA current loop, and output to a printer or a remote device.

The electronics package is also described in the overview of this section.

# Theory of Operation

The Two-Channel TransPort is a transit-time ultrasonic flowmeter based on the following principle: when ultrasonic pulses are transmitted through a moving liquid, the pulses that travel in the same direction as the fluid flow (downstream), travel slightly faster that the pulses that travel against the flow (upstream). The TransPort uses various digital signal processing techniques, including cross-correlation, to determine transit times and uses these to calculate flow velocity.

# Chapter 2

# Initial Setup

Before taking measurements, you must prepare the TransPort for operation using to the following procedures:

- Making electrical and transducer connections

- Charging and/or Replacing Batteries

- Powering On and Off

- Using the Screen and Keypad

- Obtaining On-Line Help

- Adjusting the Screen Contrast and Audio Alarm Volume

## Making Electrical Connections

Before taking measurements with the TransPort, you must make all necessary connections to the unit. This section describes how to connect the following:

- Power

- Transducers

- Analog Inputs/Outputs

- RS232 Communications Port

Make connections to the top of the TransPort unit as shown in Figure 2-1 on page 2-2. Please note that you only need to make power and transducer connections. Other connections are not necessary for basic operation.

## Power Connections
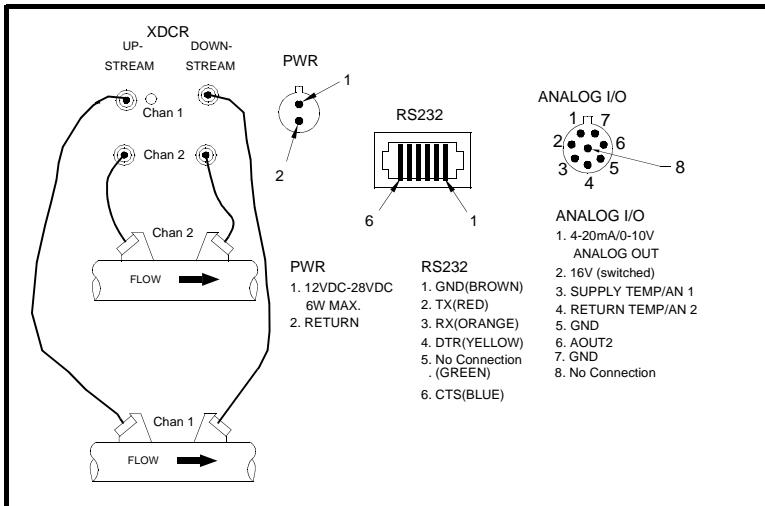


**Figure 2-1:  Connection Locations**

The TransPort is powered by either a 100-120/200-260 VAC charger/power supply, or the internal 4 C-size NiCad high-energy rechargeable batteries. When you receive the TransPort, the batteries are not charged; therefore, if you want to use the batteries to make remote measurements, you must charge the batteries following the instructions on page 2-4. In either case, you must connect the power cord to the appropriate terminal as shown in Figure 2-1 above.

## Transducer Connections

The two sets of transducer cables connect to the TransPort with LEMO® coaxial type connectors. Each color-coded cable should have a collar labeled UPSTREAM or DOWNSTREAM. Make transducer cable connections to the flowmeter as shown in Figure 2-1 above.

Because of the various types of transducers and installations, transducer installation is discussed separately in the *Liquid Transducer Installation Guide* (#916-055) provided with your user's manual.

Transducer Connections (cont.)

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**!WARNING!**
**TO ENSURE SAFE OPERATION OF THE**
**TRANSPORT, YOU MUST INSTALL AND**
**OPERATE IT AS DESCRIBED IN THIS MANUAL.**
**IN ADDITION, BE SURE TO FOLLOW ALL**
**APPLICABLE SAFETY CODES AND**
**REGULATIONS FOR INSTALLING ELECTRICAL**
**EQUIPMENT IN YOUR AREA.**

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## Analog Input/Output Connections

The Two-Channel TransPort provides two software-selectable 0-20 mA or 4-20 mA current outputs and two 4 to 20-mA analog inputs with 16 V supply for loop powered temperature transmitters. Connect the inputs/outputs using a LEMO® multi-pin connector as shown in Figure 2-1 on page 2-2. The pin numbers for the connector and the color code for the standard input/output cable are shown in Table 2-1 below.

**Table 2-1:  Pin Connections for Analog Input/Outputs**

| Pin Number | Wire Color | Description |
|:----------:|:----------:|:-----------:|
| 1 | Black | Analog Out 1 |
| 2 | Red | 16 V  (switched) |
| 3 | White | Supply Temperature |
| 4 | Yellow | Return Temperature |
| 5 | Green | Ground |
| 6 | Orange | Analog Out 2 |
| 7 | Blue | Ground |
| 8 | Violet | No Connection |

## RS232 Communication Connections

The RS232 communications port provides a serial interface in order to connect a printer, terminal, computer, or other monitoring device. The RS232 cable connects to the TransPort with a 6-pin phone-type jack. Connect the RS232 cable to the appropriate location as shown in Figure 2-1 on page 2-2.

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*Initial Setup* 2-3

## RS232 Communication Connections (cont.)

Panametrics supplies the appropriate cable; however, this does not guarantee compatibility between the device and the TransPort. To verify that a particular device is compatible, compare the serial port wiring information in Appendix D to the information given in the operator's manual for the serial device. If there is a wiring compatibility problem, contact Panametrics for a special cable.

# Charging and/or Replacing Batteries

When you receive the TransPort you will need to charge the batteries. When fully charged, the batteries provide 4 to 6 hours of continuous operation.

To recharge the batteries, simply plug the AC power module cord into the power jack as shown in Figure 2-1. When the TransPort is plugged into line voltage, the internal battery charger automatically recharges the batteries while simultaneously powering the flowmeter.

Recharging usually takes between 16 to 20 hours from complete depletion. The TransPort will not overcharge batteries. When batteries are low, a "LOW BATTERY" message appears on the top of the screen. You should recharge the batteries immediately; otherwise, the TransPort will display a "VERY LOW BATTERY" message, beep 10 times, and automatically shut off in order to preserve the remaining battery energy.

If for any reason you need to replace the rechargeable batteries, use 4-C size NiCad high energy rechargeable batteries (Panametrics P/N 200-044). To replace the batteries, open the panel located on the back of the TransPort unit, disconnect the batteries, and replace with new ones (see Figure 2-2 on page 2-5).

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**Caution!**
Replace batteries only with the specified
rechargeable NICd batteries. Do not attempt to
recharge non-rechargeable batteries.

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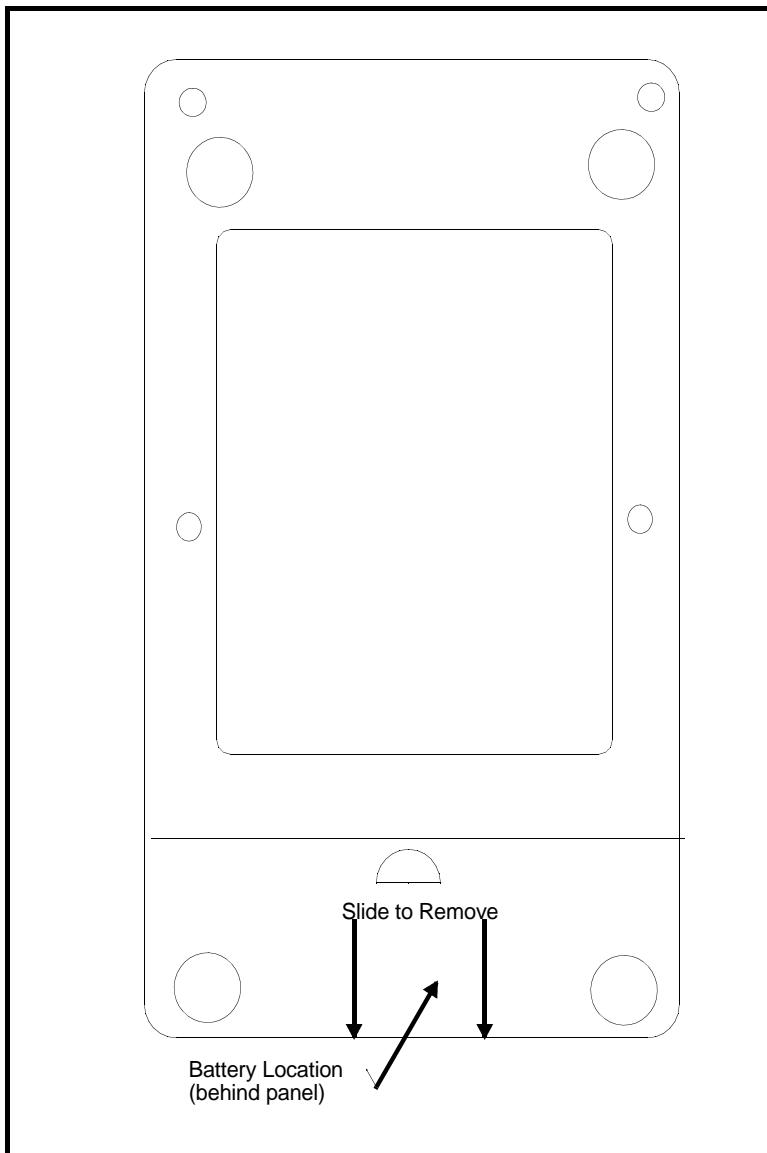
**Figure 2-2: NiCad Battery Location**

## Powering On and Off

**!WARNING!**
**TO ENSURE SAFE OPERATION OF THE
TRANSPORT, YOU MUST INSTALL AND
OPERATE IT AS DESCRIBED IN THIS MANUAL.
IN ADDITION, BE SURE TO FOLLOW ALL
APPLICABLE SAFETY CODES AND
REGULATIONS FOR INSTALLING ELECTRICAL
EQUIPMENT IN YOUR AREA.**

To operate the TransPort, the power cord must be plugged into line voltage or the battery must be charged as described earlier. To turn the TransPort on, press the [ON] key located in the upper right-hand corner of the keypad. Immediately upon power up the TransPort displays the Panametrics logo and the software version. The meter will then perform the following self checks and displays their conditions:

• EPROM checksum

• RAM test

• NOVRAM test

• Backup battery test

• Time and date test

If the meter fails any of these tests, contact Panametrics.

**!WARNING!**
**IF THE METER FAILS THE BACKUP BATTERY
TEST, YOU MUST SEND THE UNIT BACK TO
THE FACTORY FOR A BACKUP BATTERY
REPLACEMENT. MAKE SURE YOU KEEP THE
NICAD BATTERIES CHARGED UNTIL YOU ARE
READY TO SHIP THE UNIT BACK TO THE
FACTORY. BEFORE SHIPPING, PRINT OUT ALL
THE LOG AND SITE DATA.**

After the meter conducts its self checks, a screen appears similar to the one shown in Figure 2-3. To turn the TransPort off, press [SHIFT] (red key) and [ON].

# Powering On and Off (cont.)

```
┌─────────────────────────────────────────┐
│                                         │
│         ┌───────────────────────┐       │
│         │ chan1  CHAN0       *  │       │
│         │                       │       │
│         │ CH1    VELOCITY   Ft/s│       │
│         │                       │       │
│         │        12.50          │       │
│         │                       │       │
│         │ CH1 │ CH2 │ SUM │ DIF │       │
│         └───────────────────────┘       │
│                                         │
└─────────────────────────────────────────┘
```
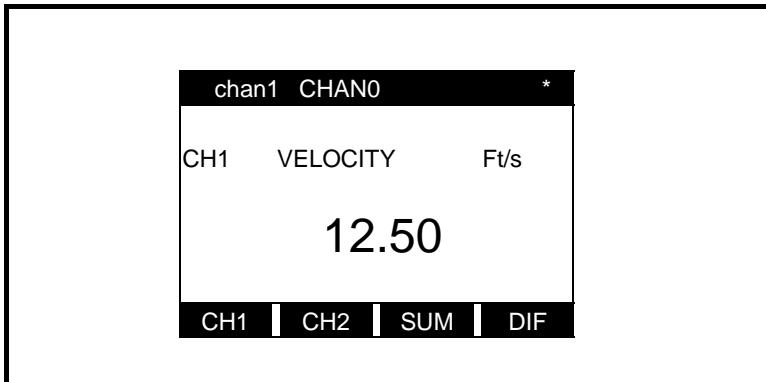
**Figure 2-3:  Screen After Powering On**

# Using the Screen and Keypad

The two essential features for operating the TransPort are the screen and keypad. Although these features are common, there are characteristics about each one that need to be explained.

## Screen

The primary function of the screen is to display information so you can accurately and easily make measurements. To do this, the TransPort screen is separated into three parts:

The top line of the screen, which appears in reverse video, is the **indicator box**. The indicator box specifies the task you are performing. For example, when you press [PROG], you enter the Program Menu, and the indicator box displays "PROGRAM." When you are not performing a task, the indicator box shows the channel number and the site file name.

**Note:** *The indicator box also lets you know when the battery is low. See page 2-4 for details on recharging the battery.*

## Screen (cont.)

At times, the indicator box also displays one of three symbols. The most common is the right arrow (see Figure 2-4 below). This arrow indicates that there are more feature key options (see page 2-9.) The feature keys are the four boxes located on the bottom of the screen.



**Indicator Box**

| chan1 CHAN0 | ➤ |

CH1     VELOCITY          Ft/s

## 12.50

**Feature Key Options**

| CH1 | CH2 | SUM | DIF |

**Work Area**
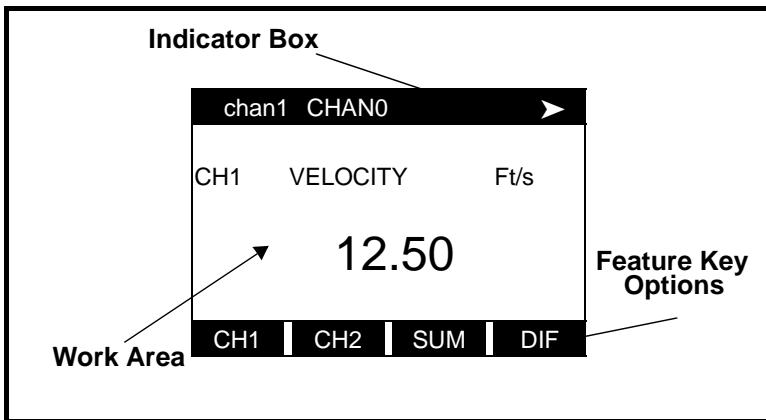
**Figure 2-4:  The Two-Channel TransPort Screen**

The other symbol is an asterisk (*). When the asterisk appears, this indicates that the TransPort is currently logging information (Data Logging is described in Chapter 6, *Logging Data*).

The third symbol is either an "S"or "$S_L$", which indicates the status of the [SHIFT] (red) key. "S" indicates the shift function is activated (for one key stroke), and "$S_L$" indicates the shift function is locked.

The indicator box also displays other messages, which will be referred to in the appropriate sections.

The middle of the screen is the **work area**, which displays measurements, graphs, menu prompts, etc. In addition, this area also displays error code messages, which are described in more detail in Chapter 10, *Diagnostics and Troubleshooting*.

## Screen (cont.)

**Note:** *The TransPort also displays a Stop Watch Timer when totalizers are activated, (see Chapter 4,* Displaying Data, *page 4-7).*

## Keypad

The TransPort keypad has 30 keys, each of which has a second function. The functions for each key are as follows (see Figure 2-5 on page 2-10):

- 4 feature keys: ([F1], [F2], [F3], [F4])- enable you to select the special functions or parameters that appear on the bottom of the screen.

- 12 numeric keys: (0-9 including - and .) - enable you to enter numeric data.

- 4 arrow keys: ([←], [→], [↑], [↓]) - enable you to move through the menu options.

- 6 task keys: (PROG, PRNT, LOG, DISP, CLR, CAL) - perform specific tasks for flowmeter operation. Each task key is described in its corresponding section in this manual.

- ENT - enters selected values into the TransPort memory.

- EXIT - enables you to exit menus or menu options at any time.

- ON - turns the power on.

- Shift key (red key) - enables you to use the second function for each key as described below.

## Keypad (cont.)

Each of these keys has a second (shift) function printed in red
above the key. For example, OFF is the shift function of the [ON]
key. Most of the second functions are used for entering text;
however, there are two keys that have special second functions:

- [SHIFT] [ENT] - enters the on-line help function, which is
  described in the following section.
- [SHIFT] [DISP] - acts as a space key when entering
  alphanumeric information.
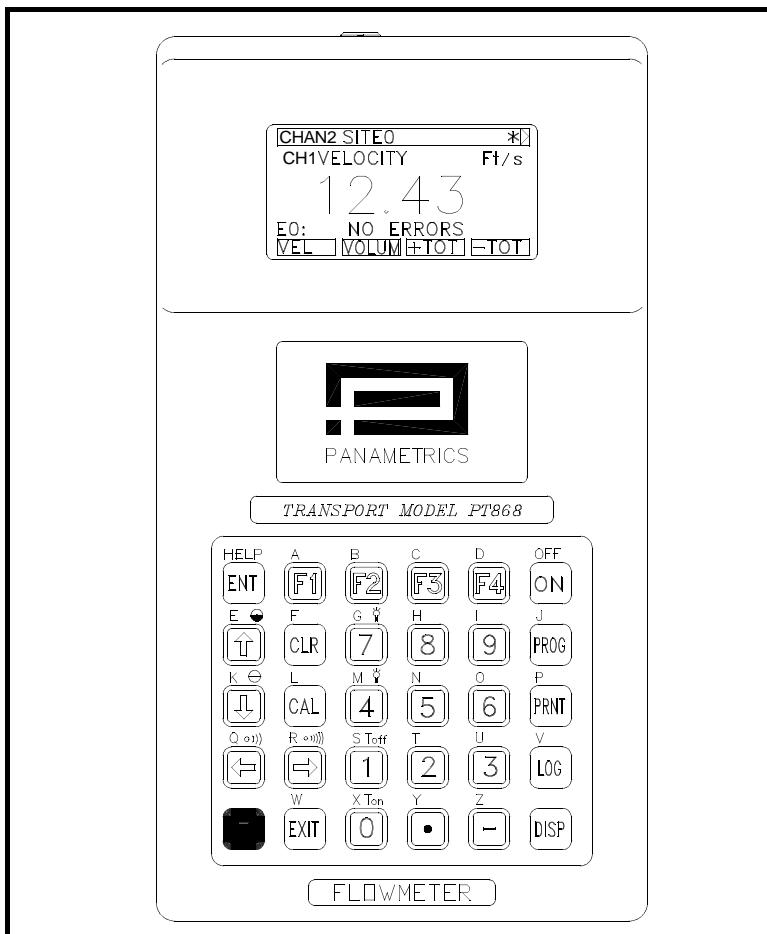


**Figure 2-5:  The Two-Channel TransPort**

Keypad (cont.)

To execute a shift function, press [SHIFT] then the desired key (an "S" appears in the indicator box to show the shift key is activated). When a key is pressed after shift is activated, the shift function is canceled. When you press the shift key twice, it locks, and an "$S_L$" appears in the indicator box. To unlock the [SHIFT] key, press it once more (the "$S_L$" symbol disappears).

The arrow keys also have a third function that enables you to adjust the screen contrast and the volume as described below.

# Obtaining On-Line Help

The Two-Channel TransPort offers on-line help screens that contain descriptions of features. You can access on-line help at any time by pressing [SHIFT] and [ENT].

When you enter help, the screen displays on-line help pertaining to the task you are performing. For example, if you enter Help while setting up the data logger, help for the data logger appears. Use the four feature key options to view on-line help details.

# Adjusting the Contrast and Audio Alarm Volume

The TransPort enables you to adjust the screen contrast and the audio alarm volume using the keypad. Refer to the appropriate section that follows to make adjustments.

**To adjust the contrast:**
Hold down the [ON] key and simultaneously press one of the following keys:

• Press the [↑] key to increase the contrast, or

• Press the [↓] to decrease the contrast.

Hold down either key for large changes or press repeatedly for small changes.

# Adjusting the Contrast and Audio Alarm Volume (cont.)

**To adjust the volume:**
Hold down the [ON] key and simultaneously press one of the following keys:

- Press the [→] key to increase the volume, or

- Press the [←] to decrease the volume.

Hold down either key for large changes or press repeatedly for small changes.

---

# Using the Back Light

To provide more visibility for the display, the TransPort can be equipped with a back light. If your unit has a back light, you can operate it as described below.

**To turn on the back light:**
Press and hold the [ON] key; then press the [7] key. To brighten the back light, press the [7] key repeatedly.

**To turn the back light off:**
Press and hold the [ON] key; then press the [4] key.

**To operate the back light time out:**
Press any key to bring the back light back to its preset level.

**Notes:** *1. If the back light is set to its brightest setting, you may have to press the [4] key more than once to turn the back light off.*
*2. Selecting Low Transmitter Voltage disables the back light (see page 3-33).*

# Chapter 3

# Programming Site Data

The Two-Channel TransPort has a Program Menu that enables you to enter information that is specific to each channel site, such as transducer types, installation configurations, pipe material, etc.

Besides channel site parameters, a set of global parameters can be entered. Global parameters are used to program site data that is not specific to either channel. Global parameters are also used to measure the sum, the average, or the difference between channels 1 and 2.

The TransPort requires you to enter the channel, system, and pipe data, as well as any necessary global data, in order to make measurements. The Program Menu also enables you to set up analog inputs and outputs, and set up an RS232 communications device.

Once you have entered all the necessary data, you can save them in files and recall them for later use. The Two-Channel TransPort can store up to 10 sets of site data. To clear data, refer to Chapter 7, *Clearing Data.*

**Note:** *The TransPort will not allow you to program more than 10 sets of site data.*

This section describes:

- How to enter the Program Menu.

- How to enter channel, system, pipe, input/output, setup, global, and communications parameters.

- How to save files.

- How to recall files.

# Entering the Program Menu

To enter the Program Menu, press the [PROG] key on the keypad.
The screen should appear similar to that shown in Figure 3-1
below. Refer to Appendix F, *Menu Maps,* Figure F-1 for a flow
diagram of the Program Menu.

**Indicates Top of Menu**     **Pointer**

**Task** → PROGRAM     Start   ➤

**Name**

PROGRAM ←     **Selection**
Channel 1 ←

CH1 | CH2 | SUM | DIF

**Menu Options**
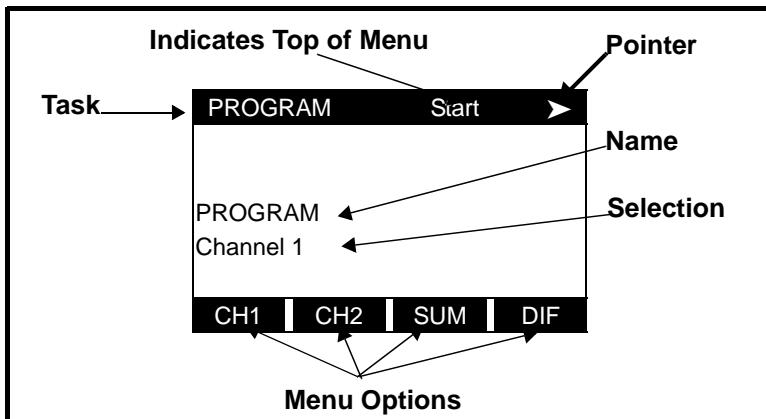
**Figure 3-1:  Screen After Pressing PROG Key**

The indicator box displays three things: the task you are
performing, which is PROGRAM; "Start," which indicates you
are at the beginning of the Program Menu; and the pointer, which
indicates that there are more options in the displayed menu. Use
the [←] and [→] keys to view all the menu options in the
Program Menu.

# Entering the Program Menu (cont.)

Parameters are entered into the program using two menu levels. The first menu level in the program contains the main menu options. They are as follows:

- CH1/CH2 — enables you to activate channel 1/channel 2 and enter system, pipe, input/output, and setup data specific to each channel.

- GLOBL — enables you to enter a variety of data not specific to either channel, such as date and time, system units, display options, inputs/outputs, and communications parameters.

- SAVE — enables you to save and store all global and channel site data simultaneously in one file.

- RECLL — lets you recall a particular file.

The second menu level in the program contains the submenu options, which are located within the Channel and Global menus. These submenu options enable you to set up parameters that are specific to channel sites and to global measurements. (Refer to the specific section for an overview of these second level options.)

Use the following sections to program the desired information into the TransPort. Remember, after you enter the desired information, refer to page 3-45 to save the data.

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

# Entering Channel Parameters

The first two menu options in the Program are the CH1 and CH2 Menus. To enter the Channel Menus, press the [F1] or [F2] key. A screen similar to Figure 3-2 below appears. Refer to Appendix F, *Menu Maps*, Figure F-1A for a flow diagram of the Channel Menu options.
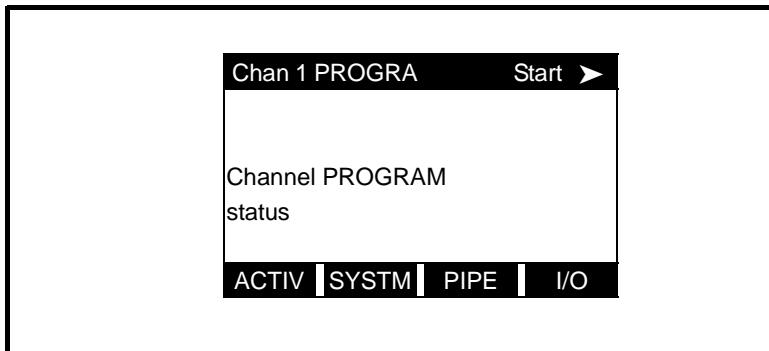


**Figure 3-2:  Screen After Entering Channel Option**

Both Channel Menus contain the same submenus, which are programmed independently, as follows:

- ACTIV — enables you to activate a channel.

- SYSTM — enables you to enter the channel label, measurement units, and the energy option for each channel.

- PIPE — enables you to enter pipe geometry, transducer, and fluid information for each channel.

- I/O — lets you enter data to set up the zero cutoff for each channel.

- SETUP — enables you to set signal limits and response times for each channel.

## Activating Channels

The first option in the Channel Menu is ACTIV. To display the
Channel status, press the [F1] key.

### Selecting the Channel Status

The next prompt enables you to turn off or activate the selected
channel. Use the appropriate feature key to respond:

- Press [F1] if you want to turn off the selected channel.

- Press [F2] if you want to activate the selected channel.

The TransPort will return to the Channel Menu.

**Note:** *At least one channel must be active at all times.*

---

# Entering System Parameters

The second option in the Channel Menu is SYSTM. This option
enables you to activate the energy option, enter a channel label
and message, enter measurement and totalizer units, and specify
display decimal digits for each channel.

To enter the SYSTM option, press the [F2] key. A screen similar
to Figure 3-3 below appears. Refer to Appendix F, *Menu Maps,*
Figure F-1C for a flow diagram of the SYSTM option.

```
 Chan 1    SYSTM
Channel PROGRAM
System


ENERGY OPTION
OFF
  OFF     ON           
```
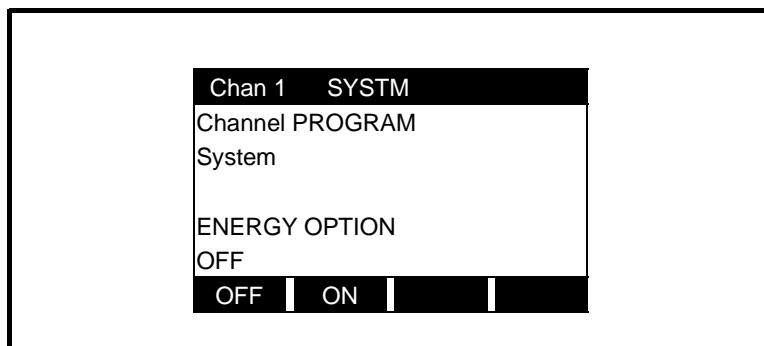
**Figure 3-3: Screen After Pressing SYSTM Key**

# Entering System Parameters (cont.)

Once you enter this menu, the following prompts will appear:

- Energy Option

- Channel Label

- Channel Message

- Volumetric Units

- Vol Decimal Digits

- Totalizer Units

- Total Decimal Digits

- Power Units (for energy only)

- Power Decimal Digits (for energy only)

- Energy Total (for energy only)

- Energy Decimal Digits (for energy only)

- Heating or Cooling SYSTM (for energy only)

Use the steps that follow to enter system parameters.

### Step 1: Choosing the Energy Option
The first prompt enables you to measure energy. Use the appropriate feature key to respond:

- Press [F1] if you do not want to measure energy flow rate (turn energy option off).

- Press [F2] if you do want to measure energy flow rate (turn energy option on).

If you choose to measure energy flow rate, the TransPort will ask additional questions within this menu.

**Note:** *To measure energy you must have either two temperature inputs connected to the analog inputs or you must enter two fixed temperatures into the TransPort as described on page 3-26.*

# Entering System Parameters (cont.)

## Step 2: Entering the Channel Label

The second prompt enables you to enter a label for the selected channel. Use the red [SHIFT] key and the numeric keys to enter a channel label, then press the [ENT] key.

## Step 3: Entering the Channel Message

At this prompt, enter a brief description of the measurement being made on this channel. Because the TransPort can store up to 10 pairs of channel labels (one pair for each site name), this prompt provides enough space to enter a description up to 21 characters long so you can distinguish one measurement from another.

Use the red [SHIFT] key and the numeric keys to enter a Channel Label; then press the [ENT] key.

**Note:** *Assigning channel labels and messages does not save data. Labels and messages are for clarification only. To save setup data, you must use the Program Menu Save command (see page 3-45).*

## Step 4: Choosing Volumetric Units

To select the units for volumetric flow rate:

**1.** Use the arrow keys to view all the options available. See Table 3-1 on page 3-8 for a list of available volumetric units.

**2.** Press the appropriate feature key to make a selection.

**Note:** *The choices available for Volumetric Units will depend on the System Units (English or Metric) selected in the Global System Units option  (see page 3-37).*

## Step 5: Selecting the Volumetric Decimal Digits

This option enables you to select the number of digits to the right of the decimal for volumetric flow rate. Use the appropriate feature key to choose a number from 0 to 3.

## Entering System Parameters (cont.)

**Table 3-1:  Volumetric Unit Options**

| English Volumetric Units | Metric Volumetric Units |
|---|---|
| GAL/S - U.S. Gallons per Second | L/S- Liter per Second |
| GAL/M - U.S. Gallons per Minute | L/M - Liters per Minute |
| GAL/H - U.S. Gallons per Hour | L/H - Liters per Hour |
| MGD - Millions of U.S. Gallons per Day | ML/D - Millions of Liters per Day |
| $ft^3/s$ - Cubic Feet per Second | $m^3/s$ - Cubic Meters per Second |
| $ft^3/m$ - Cubic Feet per Minute | $m^3/m$- Cubic Meters per Minute |
| $ft^3/h$ - Cubic Feet per Hour | $Mm^3/h$ - Millions of Cubic Meters per Hour |
| $Mf^3/d$ - Millions of Cubic Feet per Day | $Mm^3/d$- Millions of Cubic Meters per Day |
| BBL/S - Barrels per Second | BBL/S - Barrels per Second |
| BBL/M - Barrels per Minute | BBL/M - Barrels per Minute |
| BBL/H - Barrels per Hour | BBL/H - Barrels per Hour |
| MBL/D - Millions of Barrels per Day | MBL/D - Millions of Barrels per Day |

# Entering System Parameters (cont.)

### Step 6: Choosing Totalizer Units

To select the units for totalized flow:

1. Use the arrow keys to view all the options available.  See Table 3-2 below for a list of available totalizer units.

2. Press the appropriate feature key to make a selection.

**Note:** *The choices available for Totalizer Units will depend on the System Units (English or Metric) selected in the Global System Units option (see page 3-37).*

**Table 3-2:  Totalizer Unit Options**

| English Totalizer Units | Metric Totalizer Units |
|---|---|
| Gal - U.S. Gallons | L - Liters |
| MGAL - Mega U.S. gallons | ML - Megaliters |
| $ft^3$ - Cubic Feet | $m^3$ - Cubic Meters |
| $Mft^3$ - Mega Cubic Feet | $Mm^3$ - Mega Cubic Meters |
| BBL - Barrels | BBL - Barrels |
| MBBL - Megabarrels | MBBL - Megabarrels |

### Step 7: Selecting the Total Decimal Digits

This option enables you to select the number of digits to the right of the decimal for total flow rate. Use the appropriate feature key to choose a number from 0 to 3.

### Step 8: Choosing Power Units

If you chose to measure energy earlier in SYSTM, the TransPort will next prompt you to choose the power units. If you chose not to measure energy, the display returns to the Channel Menu.

To select the units for power:

1. Use the arrow keys to view all the options available. See Table 3-3 on page 3-10 for a list of available power units.

2. Press the appropriate feature key to make a selection.

# Entering System Parameters (cont.)

**Note:** *The choices available for Power Units will depend on the System Units (English or Metric) selected in the Global System Units option (see page 3-37).*

### Table 3-3:  Power Unit Options

| English Power Units | Metric Power Units |
|---|---|
| kBTU - Thousands of British Thermal Units per Hour | kCALs - Thousands of calories per Second |
| MMBTU - Millions of British Thermal Units per Hour | MCALs - Millions of Calories per Second |
| kW - Kilowatts | kW - Kilowatts |
| TONS - Tons | MW - Megawatts |

## Step 9: Selecting the Power Decimal Digits

This option enables you to select the number of digits to the right of the decimal for power units. Use the appropriate feature key to choose a number from 0 to 3.

## Step 10: Choosing Total Energy Units

To select the units for Total Energy:

**1.** Use the arrow keys to view all the options available. See Table 3-4 for a list of available power units.

**2.** Press the appropriate feature key to make a selection.

**Note:** *The choices available for Energy Units will depend on the System Units (English or Metric) selected in the Global System Units option (see page 3-37).*

# Entering System Parameters (cont.)

**Table 3-4:  Total Energy Unit Options**

| English Energy Units | Metric Energy Units |
|---|---|
| kBTU - Thousands of British Thermal Units | kCAL - Kilocalories |
| MMBTU - Millions of British Thermal Units | MCAL - Megacalories |
| kWHr - Kilowatt-Hours | kWHr - Kilowatt-Hours |
| TONS - Tons | MWHr - Megawatt-Hours |

### Step 11: Selecting the Energy Decimal Digits

This option enables you to select the number of digits to the right of the decimal for energy units. Use the appropriate feature key to choose a number from 0 to 3.

### Step 12: Choosing Heating or Cooling System

This prompt asks you select whether you are making measurements in a heating or cooling system.

• Press [F1] for Cooling, or

• Press [F2] for Heating.

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

# Entering Pipe Parameters

The third option in the Channel Menu is PIPE. This option
enables you to enter information for the pipe characteristics and
transducers for each channel. You must enter these parameters in
order to make flow measurements.

To enter the PIPE option, press the [F3] key. A screen similar to
Figure 3-4 below appears. Refer to Appendix F, *Menu Maps*,
Figures F-1D and F-1E for flow diagrams of the PIPE options.

```
  Chan 1     PIPE PROG
Channel PROGRAM
Pipe parameters

TRANSDUCER NUMBER
40
  SPEC  ▐        ▐        ▐
```
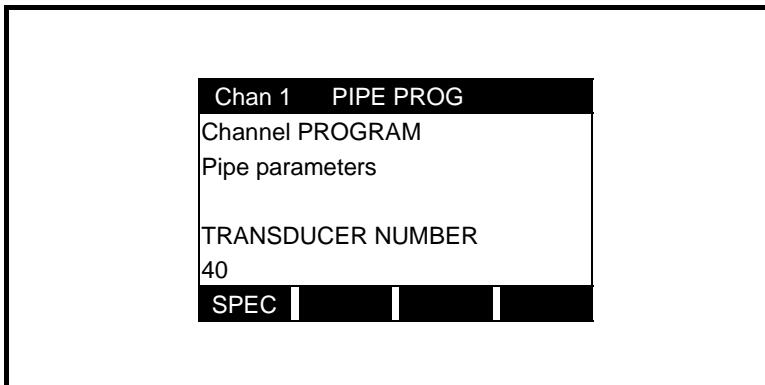
**Figure 3-4:  Screen After Pressing PIPE Key**

The series of prompts that appear depend on the type of
transducers you are using. The first prompt asks you to enter the
transducer number that is engraved on the head of the transducer.
This number signifies the type of transducer: wetted or clamp-on
(standard or medium/high temperature). When you enter the
transducer number, the TransPort recognizes the type of
transducer and proceeds to asks you for the needed pipe
information for that transducer type.

This section describes how to enter pipe parameters for all
<u>standard </u>transducer types. If you are using a special transducer
and need to enter pipe parameters, refer to Appendix C. Use the
steps that follow to program your unit.

# Entering Pipe Parameters (cont.)

**Note:** *Refer to the* Liquid Transducer Installation Guide *(916-055) for additional information about transducers and configurations.*

### Step 1: Entering the Transducer Number

Transducer numbers are separated into the following categories:

- 1-3 indicates Rayleigh-wave type clamp-on transducers

- 10-39 indicates Shear wave clamp-on transducers

- 40-74 indicates wetted transducers

- 91-99 indicates special clamp-on application transducers

- 112-139 indicates medium and high temperature clamp-on transducers.

**Note:** *Not all transducer numbers are valid. Invalid transducer numbers will be rejected.*

Use the numeric keys to enter the transducer number and press [ENT].

Depending on the transducer you are using, do one of the following:

- If you are using clamp-on transducers (#1-3, 10-39, or 112-139), follow the instructions in *Entering Parameters for Clamp-On Transducers*, page 3-14.

- If you are using wetted transducers (#40-74), follow the instructions in *Entering Parameters for Wetted Transducers*, on page 3-20.

- f you are using special transducers (#91-99), refer to Appendix C for instruction for entering pipe parameters.

## Entering Parameters for Clamp-On Transducers

If you are using clamp-on transducers, you will get the following prompts:

- Wedge Temperature Input (for medium or high temperature)

- Pipe Material

- Pipe O.D. (pipe outside diameter)

- Pipe Wall Thickness

- Lining (material and thickness)

- Fluid Type

- Reynolds Correction Factor

- Calibration Factor

- # of Traverses

- Transducer Spacing

### Step 2C: Entering the Wedge Temperature

If you are using medium to high temperature transducers, you must enter the wedge temperature. If not, proceed to Step 3C. Use the appropriate feature key to respond.

- Press [F1] for an active input (not yet implemented).

- Press [F2] for a fixed input.

If you choose to have a fixed input the TransPort prompts you to enter a temperature for the transducer wedge. This temperature needs only be approximate and allows correction of the wedge sound speed for temperature.

### Step 3C: Entering the Pipe Material

This prompt asks you to enter the pipe material. Since clamp-on transducers send their ultrasonic signals through the pipe wall, the sound speed of the pipe material must be factored in to obtain an accurate flow measurement. Clamp-on transducers are applicable on a variety of pipe materials, only a few of which, are among the options for this prompt. If your pipe material is not among the options, select "OTHER" and enter the sound speed of your pipe material from the tables in Appendix B.

## Entering Parameters for Clamp-On Transducers (cont.)

Use the following steps to enter the pipe material:

**1.** Use the arrow keys to view all the pipe material choices. See Table 3-5 below for the available materials.

**2.** Press the appropriate feature key to choose the desired materials.

**3.** Depending on the pipe material choice, the TransPort may ask for further information. See Table 3-5 below for the various pipe materials available. If required, press the appropriate feature key to choose the desired material.

**Table 3-5:  Pipe Materials**

| Pipe Material Category | Specific Material |
|---|---|
| Steel | Carbon Steel or Stainless Steel |
| Iron | Ductile Iron or Cast Iron |
| Cu - Copper | None |
| Al - Aluminum | None |
| Brass | None |
| CuNi - Copper/Nickel | 70% Cu/30% Ni or 90% Cu/10% Ni |
| Glass | Pyrex, Flint, or Crown |
| Plastic | Nylon, Polyester, Polypropylene, PVC (CPVC), or Acrylic |
| Other* | User Defined |

*If you select "OTHER," the TransPort prompts you to enter the sound speed of the pipe material.

**Note:** *When you select "OTHER," before entering a value, the TransPort displays the value for speed of sound of the last selected material.*

## Entering Parameters for Clamp-On Transducers (cont.)

### Step 4C: Entering the Outside Diameter of the Pipe

This prompt for clamp-on transducers asks for the pipe outside diameter (OD). If you do not know the outside diameter of your pipe, use either the on-line help or consult Appendix B, which contains some standard pipe sizes with their corresponding outside diameters. For greater accuracy, measure the pipe OD at the location where the transducers will be mounted.

To enter the outside diameter:

1. Press the appropriate feature key to select the units.

2. Use the numeric keys to enter the outside diameter.

3. As an alternative, use "in/PI" or "ft/PI" to enter circumference. The TransPort will calculate the outside diameter after you enter a numeric value. Press "inch" or "feet" to see that calculated value of OD.

4. Press [ENT].

### Step 5C: Entering the Pipe Wall Thickness

This prompt asks you to enter the thickness of the pipe wall. If you are not sure of the pipe wall thickness, use either the on-line help or consult Appendix B, which contains some standard pipe sizes with their corresponding wall thicknesses. For greater accuracy, the pipe wall thickness can be determined by using the optional internal ultrasonic thickness gage as described in Chapter 9, *Using the Ultrasonic Thickness Gauge.*

Use the numeric keys to enter the pipe wall thickness, then press [ENT].

## Entering Parameters for Clamp-On Transducers (cont.)

### Step 6C: Entering Pipe Lining

This prompt asks you to enter the pipe lining material. Clamp-on transducers can be used on pipes with a variety of pipe linings; however, only a few are among the available options. If your lining is not among the options, select "OTHER" and enter the sound speed of your lining material from the tables in Appendix B.

If your pipe does not have a lining, press [F1] to respond no, and the TransPort will proceed to the next prompt.

If your pipe does have a lining, use the following steps to enter lining information:

1.  Press [F2].

2.  The next prompt asks you to choose the lining material. Use the appropriate feature key to respond.

**Notes:** *1. If you choose "OTHER," the TransPort asks you to enter the lining sound speed. If you do not know the lining sound speed, Appendix B lists some standard materials and their corresponding sound speeds.*

*2. When you select "OTHER," before entering a value, the TransPort displays the value for speed of sound of the last selected material.*

3.  The next prompt asks you to enter the pipe lining thickness. Use the numeric keys to enter the lining thickness.

4.  Press [ENT].

## Entering Parameters for Clamp-On Transducers (cont.)

### Step 7C: Entering the Fluid Type

This prompt asks you to enter the fluid type. You may choose one of the following:

- Water

- Water/glycol mixture (for energy option only)

- Oil (lube or crude)

- Methanol

- Ethanol

- LN2

- Freon

- Other

Use the appropriate feature key to make a choice. Depending on the fluid type you choose, the TransPort may ask you for additional information.

### Step 8C: Entering the Reynolds Correction Factor

This prompt lets you enable or disable the Reynolds Correction Factor, which is a number based on the Kinematic Viscosity and flow rate of the fluid. Generally, it should only be enabled when using transducers mounted in a diametrical path (such as clamp-on or tilted diameter). If you enable the Reynolds Correction Factor, you will also need to enter the Kinematic Viscosity of the fluid (units are $ft^2/sec$ or $m^2/sec$ depending on the units selected). Refer to Appendix B for the Kinematic Viscosity of your fluid.

To disable the Reynolds Factor, press [F1]. To enable it, do the following:

1. Press [F2].

2. The next prompt asks you to enter the Kinematic Viscosity. Use the numeric keys to enter the Kinematic Viscosity. The default value is for water at 20°C.

## Entering Parameters for Clamp-On Transducers (cont.)

**Note:** *When water is the fluid, the TransPort automatically selects Kinematic Viscosity for water at the selected temperature.*

**3.** Press [ENT].

### Step 9C: Entering the Calibration Factor
This prompt asks you to enter a value for the Calibration Factor, which is used as a reference for the flowmeter electronics to ensure accurate readings. Generally, if you enable the Reynolds Correction Factor, the correction factor should be set to 1.00. Otherwise the typical factor is between .90 and 1.00.

Use the numeric keys to enter a value and press [ENT].

### Step 10C: Entering the Number of Traverses
This prompt asks you to enter the number of times the ultrasonic signal will traverse the pipe (refer to the *Liquid Transducer Installation Guide* (916-055)). The number of traverses is determined by such factors as pipe sizes, pipe wall absorption properties, and accuracy desired. We generally recommend trying two-traverse first.

Use the arrow keys to view all the options, then press the appropriate feature key to respond.

### Step 11C: Display of Transducer Spacing
This prompt displays the actual spacing of the transducers calculated from the information entered. Use the *Liquid Transducer Installation Guide* to install the transducers on the pipe with the spacing dimension (S) given here. Set the transducers to the spacing shown at this prompt.

**Note:** *The spacing calculated by the meter can be overwritten (using the numeric keys) if necessary to match the actual physical spacing of the transducers. Do not change the spacing by more than ±10% from the S calculated by the meter.*

## Entering Parameters for Clamp-On Transducers (cont.)

You have completed entering data into the PIPE option. You may at this time do one of the following:

• Use the up and down arrow keys to verify or change data.

• Continue to enter data using other Program Menu options as described in this section.

• Save the entered parameters as described on page 3-45.

• Press the [EXIT] key to begin taking measurements. If you press [EXIT] without saving, the TransPort gives you the opportunity to save. Refer to page 3-45 to save setup data.

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

*If you decide to exit, you must have already programmed the system parameters in order to make flow measurements.*

## Entering Parameters for Wetted Transducers

If you are using wetted transducers, you will get the following prompts:

• Pipe O.D. (pipe outside diameter)

• Pipe Wall

• Path Length (P)

• Axial Dimension (L)

• Fluid Type

• Reynolds Correction Factor

• Calibration Factor

**Step 2W: Entering the Outside Diameter of the Pipe**
The first prompt for wetted transducers is pipe outside diameter (OD). If you do not know the outside diameter of your pipe, use either the on-line help or consult Appendix B, which contains some standard pipe sizes with their corresponding outside diameters. For greater accuracy, measure the pipe OD at the location where the transducers will be mounted.

## Entering Parameters for Wetted Transducers (cont.)

To enter the outside diameter:

**1.** Press the appropriate feature key to select the units.

**2.** Use the numeric keys to enter the outside diameter.

**3.** As an alternative, use "in/PI" or "ft/PI" to enter circumference. The TransPort will calculate the outside diameter after you enter a numeric value. Press "inch" or "feet" to see that calculated value of OD.

**4.** Press [ENT].

### Step 3W: Entering the Pipe Wall Thickness

This prompt asks you to enter the thickness of the pipe wall. If you are not sure of the pipe wall thickness, use either the on-line help or consult Appendix B, which contains some standard pipe sizes with their corresponding wall thicknesses. For higher accuracy, the pipe wall thickness can be determined by using the optional internal ultrasonic thickness gage as described in Chapter 9.

Use the numeric keys to enter the pipe wall thickness and press [ENT].

### Step 4W: Entering the Path Length (P)

This prompt asks you to enter the path length (P) of the ultrasonic signal. Panametrics has calculated the path length based on the transducer configuration for your particular application. Find the path length on the flowcell or on other supplied documentation.

**1.** Press the appropriate feature key to select the desired units.

**2.** Use the numeric keys to enter the path length.

**3.** Press [ENT].

**Note:** *If the path length is not supplied, refer to Appendix C to measure the path length.*

## Entering Parameters for Wetted Transducers (cont.)

### Step 5W: Enter the Axial Length (L)

This prompt asks you to enter the axial length (L) of the ultrasonic signal. Panametrics has calculated the axial dimension based on the transducer configuration for your particular application. Find the axial dimension on the flowcell or from other supplied documentation.

**1.** Press the appropriate feature key to select the desired units.

**2.** Use the numeric keys to enter the axial length.

**3.** Press [ENT].

**Note:** *If the axial length (L) is not supplied, refer to Appendix C to measure the axial length.*

### Step 6W: Entering the Fluid Type

This prompt asks you to enter the fluid type. You may choose one of the following:

• Water

• Water/glycol mixture (for energy option only)

• Oil (lube or crude)

• Methanol

• Ethanol

• LN2

• Freon

• Other

Use the appropriate feature key to make a choice. Depending on the fluid type you choose, the TransPort may ask you for additional information.

**Note:** *If you select "OTHER," the TransPort prompts you to enter the sound speed of the fluid.*

Entering Parameters for Wetted Transducers (cont.)

**Step 7W: Entering the Reynolds Correction Factor**

This prompt lets you enable or disable the Reynolds Correction Factor, which is a number based on the Kinematic Viscosity and the flow rate of the fluid. Generally, it should only be enabled when using transducers mounted in a diametrical path (such as clamp-on or tilted diameter). If you enable the Reynolds Correction Factor, you will also need to enter the Kinematic Viscosity of the fluid (units are in $ft^2$/sec or $m^2$/sec, depending on the units selected). Refer to Appendix B for the Kinematic Viscosity of your fluid.

To disable the Reynolds Factor, press [F1]. To enable it, do the following:

1. Press [F2].

2. The next prompt asks you to enter the Kinematic Viscosity. Use the numeric keys to enter the Kinematic Viscosity. The default value is for water at 20°C.

**Note:** *When water is the fluid, the TransPort automatically selects Kinematic Viscosity for water at the selected temperature.*

3. Press [ENT].

**Step 8W: Entering the Calibration Factor**

This prompt asks you to enter a value for the Calibration Factor, which is used as a reference for the flowmeter electronics to ensure accurate readings. Generally, if you enable the Reynolds Correction Factor, the correction factor should be set to 1.00. Otherwise the typical factor is between 0.90 and 1.00.

Use the numeric keys to enter a value and press [ENT].

## Entering Parameters for Wetted Transducers (cont.)

You have completed entering data into the Pipe Menu. You may at this time do one of the following:

- Use the up and down arrow keys to verify or change data.

- Continue to enter data using other Program Menu options as described in this section.

- Save the entered parameters as described on page 3-45.

- Press the [EXIT] key to begin taking measurements. If you press [EXIT] without saving, the TransPort gives you the opportunity to save. Refer to page 3-45 to save setup data.

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

*If you decide to exit, you must have already programmed the SYSTM parameters in order to make flow measurements.*

# Entering Input/Output Parameters — I/O

The fourth option in the Channel Menu is Input/Output. This
option enables you to enter information to set up the analog
inputs for each channel. To enter the Input/Output option, press
[F4]. A screen similar to Figure 3-5 below appears. Refer to
Appendix F, *Menu Maps*, Figure F-1F for a flow diagram of the
I/O option.

```
 Chan 1    I/O
Channel PROGRAM
Input/output

ZERO CUTOFF
0.020    Ft/s
```
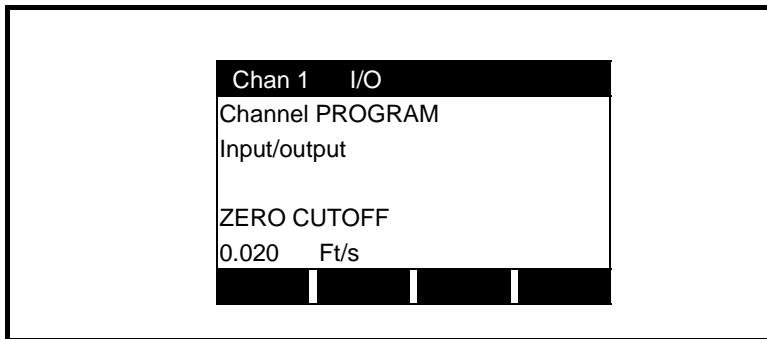
**Figure 3-5:  Screen After Pressing I/O Key**

Once you enter this menu, the following prompts will appear:

- Zero Cutoff

- Temperature Input Supply (for energy)

- Temperature (if supply is fixed)

- Temperature Input Return (for energy)

- Temperature (if return is fixed)

Use the steps that follow to enter the input/output parameters.

# Entering Input/Output Parameters —I/O (cont.)

### Step 1: Setting the Zero Cutoff

The first prompt asks you to set the zero cutoff. Near "zero" flow, the TransPort may have fluctuating readings due to small offsets (caused by such things as thermal drift in the fluid). The zero cutoff allows you to force the analog output reading to zero when there is such a minimal amount of flow. You can set it anywhere from 0 to 0.30 m/sec (0 to 1 ft/sec).

To set the zero cutoff:

**1.** Use the numeric keys to enter the zero cutoff.

**2.** Press [ENT].

### Step 2: Setting Temperature Inputs (Supply & Return)

If you chose to measure energy on the selected channel, the TransPort will prompt you for information regarding the supply and return temperature inputs.

The TransPort can accept "active" analog inputs from temperature transmitters, or you can enter "fixed" constant temperature values from the keypad. The following prompts ask you to enter which type of inputs, "active" or "fixed," you are using for the supply and return temperature.

Supply and return temperatures can be both "active," both "fixed," or one "active"and one "fixed."If you choose a "fixed" input, the TransPort will also ask you to enter the constant temperature. If you are using an "active" temperature input, it must be connected to the analog input/output port as described on page 2-3.

# Entering Input/Output Parameters —I/O (cont.)

To set up for "active" supply and/or return temperature inputs:

**1.** Press [F1] to select an active temperature input supply.

**2.** Press [F1] to select an active temperature input return.

To set up for "fixed" supply and/or return temperature inputs:

**1.** Press [F2] to select a fixed temperature input supply.

**2.** Enter a value for the fixed temperature input supply, then press [ENT].

**3.** Press [F2] to select a fixed temperature input return.

**4.** Enter a value for the fixed temperature input return, then press [ENT].

You have completed entering data into the Input/Output option. You may at this time do one of the following:

• Use the up and down arrow keys to verify or change data.

• Continue to enter data in other menus as described in this section.

• Save the entered parameters as described on page 3-45.

• Press the [EXIT] key to begin taking measurements. If you press [EXIT] without saving, the TransPort gives you the opportunity to save. Refer to page 3-45 to save the setup data.

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

*If you decide to exit, you must have already programmed the SYSTM and pipe parameters in order to make flow measurements.*

# Entering Setup Parameters

The fifth option in the Channel Menu is SETUP. This option enables you to set signal limits and response time for each channel. To enter the SETUP option, use the arrow keys to scroll through the options until "SETUP" appears on the screen, then press [F1]. A screen similar to Figure 3-6 below appears. Refer to Appendix F, *Menu Maps,* Figure F-1G for a flow diagram of the SETUP option.

```
┌─────────────────────────────┐
│ Chan 1    SETUP             │
│ Channel PROGRAM             │
│ SETUP                       │
│                             │
│ SETUP                       │
│ signal                      │
│ SIGNL   AVRG    INIT        │
└─────────────────────────────┘
```
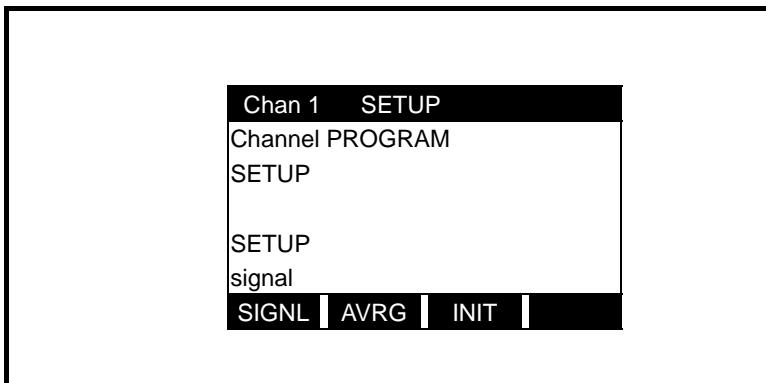
**Figure 3-6:  Screen After Pressing SETUP Key**

Once you enter this submenu, the following prompts will appear:

• SIGNL - enables you to set the limits and other parameters that affect the transducer signal.

• AVRG - enables you select a response time.

• INIT - enables you set all the setup parameters to their default values.

Use the sections that follow to enter setup parameters.

## Entering Signal Limits

The SIGNL option enables you to set the limits for the incoming signal and other parameters that affect the transducer signal. For example, you can adjust the low and high limits of the transducer signal strength. When the signal falls outside the programmed limits, the TransPort alarm sounds.

To enter the SIGNL option, press [F1]. Once you enter this menu, the following prompts will appear:

- low and high limits for the transducer signal strength

- limit for the transducer signal quality (correlation peak)

- low and high limits for the sound speed of your fluid

- low and high velocity limits

- acceleration limit(s)

- low and high limits of the amplitude discriminator

- Delta T offset

- percent of peak

- transmitter voltage

- transmitter sample size

When the reading is outside the acceptable programmed limits, the TransPort trips the alarm. Use the steps that follow to set limits.

### Step 1: Setting the Transducer Signal Low Limit

At this prompt enter the low limit for the transducer signal coming into the TransPort. This value is set to 25 by default. Press [ENT] to accept the current setting. To change the current setting, use the numeric keys to enter a new value and press [ENT]. Acceptable values are between -20 and 100.

The E1: LOW SIGNAL error message comes on when the signal strength falls below the low limit that you set.

## Entering Signal Limits (cont.)

### Step 2: Setting the Transducer Signal High Limit

Enter the high limit for the transducer signal coming into the TransPort. This value is set to 85 by default. Press [ENT] to accept the current setting. To change the current setting, use the numeric keys to enter a new value and press [ENT]. Acceptable values are between 25 to 100.

### Step 3: Setting the Correlation Peak

This prompt asks you to select the acceptable low limit for the transducer signal quality. This value is set to 100 by default. To accept the current value, press [ENT]. To change the current value, use the numeric keys to enter a new value and press [ENT]. Acceptable values are between 0 to 500.

The E4: SIGNAL QUALITY error message appears if the signal quality falls outside the set limit.

### Step 4: Entering the Sound Speed Limit

Enter the acceptable limits for the sound speed based on the conditions in your SYSTM. This value is set to 20% by default. To accept the current value, press [ENT]. To change the current value, use the numeric keys to enter a new value and press [ENT]. Acceptable values are between 1 to 50 percent.

The E2: SOUND SPEED ERROR message appears if the calculated fluid sound speed exceeds the fluid sound speed entered in the SYSTM menu by more than this limit.

### Step 5: Entering the Low Limit for Velocity

Enter the acceptable low limit for the velocity. To accept the current value, press [ENT]. The default is -40.0 ft/s. To change the current value, use the numeric keys to enter a new value and press [ENT]. Acceptable values are between -100 to 100 ft/s.

Entering Signal Limits (cont.)

### Step 6: Entering the High Limit for Velocity

Enter the acceptable high limit for the velocity. To accept the current value, press [ENT]. The default is 40.0 ft/s. To change the current value, use the numeric keys to enter a new value and press [ENT]. Acceptable values are between -100 to 100 ft/s.

The E3: VELOCITY RANGE error message appears if the calculated velocity exceeds this limit.

### Step 7: Entering the Acceleration Limit

Enter the acceptable acceleration limit for detecting cycle skipping. The default is 15.0 ft/s. To accept the current value, press [ENT]. To change the current value, use the numeric keys to enter a new value and press [ENT]. Acceptable values are between 0 to 100 ft/s.

The E6: AMPLITUDE ERROR message appears if the velocity changes by more than this limit from one reading to the next.

### Step 8: Setting the Low Limit for the Amplitude Discriminator

This prompt asks you to enter the acceptable low limit for the amplitude discriminator. The amplitude discriminator measures the size of the transducer signal sent from the TransPort. This value is set to 14 by default. Acceptable values are between 0 to 100.

To accept the current value, press [ENT]. To change the current value, use the numeric keys to enter a new value and press [ENT].

The E5: AMPLITUDE ERROR message appears if the amplitude discriminator falls outside this limit.

Entering Signal Limits (cont.)

## Step 9: Setting the High Limit for the Amplitude Discriminator

Consult Panametrics before performing this step.

This prompt asks you to enter the acceptable high limit for the amplitude discriminator. This value is set to 34 by default. Acceptable values are between 0 to 100.

To accept the current value, press [ENT]. To change the current value, use the numeric keys to enter a new value and press [ENT].

The E5: AMPLITUDE ERROR message appears if the amplitude discriminator falls outside this limit.

## Step 10: Setting the Delta-T Offset

Consult Panametrics before performing this step.

Delta-T is the difference between the upstream and downstream transit time of the transducers. You usually need to enter a Delta-T offset when you are using a test flowcell provided by Panametrics. Acceptable values are between -1000 to 1000 nsec.

To enter an offset, use the numeric keys to enter a value and press [ENT].

## Step 11: Setting the Percent of Peak

The TransPort uses the percent of peak to calculate the transit times and Delta T. This value is set to -40 percent by default. Acceptable values are between -100 to 100 percent.

To change the current value, use the numeric keys to enter a new value, then press [ENT].

## Entering Signal Limits (cont.)

### Step 12: Selecting the Transmitter Voltage
The transmitter voltage has the following two settings:

- LOW — (default) used for smaller pipes with a single-phase fluid. (This setting prolongs the life of the battery, but disables the back light.)

- HIGH — used on large pipes or pipes with more than one phase.

Use the appropriate feature key to respond.

### Step 13: Setting the Transmitter Sample Size
Consult Panametrics before performing this step.

The transmitter sample size is the number of pulses each transducer (upstream and downstream) emits. This number is set to 8 by default.

Use the appropriate feature key to respond.

## Entering Averaging Parameters

The AVRG option enables you to select the amount of time the TransPort will take to respond to a step change in flow rate. In general, the faster the response time, the less steady the reading will appear. For best results, use the Statistics option, as this increases the response time under steady flow conditions, but allows for a rapid response to changes in flow rate.

It is important to note that response times are approximate, since they can be affected by such factors as pipe geometry.

To enter the AVRG sub-option, press [F2]. The indicator box shows that you are at the beginning of the AVRG options. Use the arrow keys to view all the selections, then use the appropriate feature key to respond.

## Initializing Setup Parameters

This option lets you set all the setup parameters to their default values. To initialize setup parameters, press [F3]. Press [F1] to cancel or [F2] to initialize. The TransPort re-initializes the setup parameters when you exit the Program Menu.

This completes the Channel Menu programming section. Proceed to the next section to enter the PROG Menu GLOBL, SAVE, and RECLL options.

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

# Entering Global Parameters

The third option in the Program Menu is the GLOBL option. This option enables you to enter global parameters, which are used to program site data that is not specific to either channel, i.e., clock and communication data. More importantly, global parameters are used to program the system input and output data required to measure the sum, the average, or the difference between Channel 1 and Channel 2.

To enter the GLOBL options in the Program Menu, press the [F3] key. A screen similar to Figure 3-7 below appears. Refer to Appendix F, *Menu Maps,* Figure F-1H for a flow diagram of the GLOBL Menu options.

```
 PROGRAM          Start



Global PROGRAM
set clock


CLOCK  SYSTM    I/O   COMM
```

**Figure 3-7: Screen After Entering GLOBL Option**

Once in the GLOBL Menu, you can enter the clock and communication data; then enter the SYSTM and input/output data that you need to make combined channel measurements (SUM, DIF, AVG).

## Setting the Clock Parameters

The first option in the GLOBL Menu is the Clock option. Use this option to enter the current date and time to display. To enter the Clock option, press the [F1] key. A screen similar to Figure 3-8 below appears. Refer to Appendix F, *Menu Maps,* Figure F-1I for a flow diagram of the Clock options.

```
   Set CLOCK
Global PROGRAM
set clock

Date:      09   SEP    94
OK
   OK      EDIT
```

**Figure 3-8:  Screen After Pressing Clock Key**

### Step 1: Setting the Date

The first prompt asks you to set the date. You can accept the currently displayed date by pressing [F1], or correct it as described below:

1. Press [F2] to edit the date.

2. Use the numeric keys to enter the year.

3. Press [ENT].

4. Use the appropriate feature key to select the desired month. Use the arrow keys to view all the options.

5. Use the numeric keys to enter the day.

6. Press [ENT].

## Setting the Clock Parameters (cont.)

### Step 2: Setting the Time

This prompt asks you to set the time. You can accept the currently displayed time by pressing [F1], or correct it as described below:

**1.** Press [F2] to edit the time.

**2.** Use the numeric keys to enter the hour.

**3.** Press the appropriate feature key to select AM or PM.

**4.** Press [ENT].

**5.** Use the numeric keys to enter the minutes.

**6.** Press [ENT].

**7.** Use the numeric keys to enter the seconds.

**8.** Press [ENT].

## Entering Global System Parameters

The second option in the GLOBL Menu is SYSTM. This option enables you to enter the system units (English or Metric) and the measurement units for all combined channel measurements.

To enter the SYSTM option, press the [F2] key. A screen similar to Figure 3-9 below appears. Refer to Appendix F, *Menu Maps,* Figure F-1J for a flow diagram of the SYSTM options.

```
 Global    SYSTM
Global PROGRAM
system

SYSTEM UNITS
ENGLISH
  ENG   METRC
```
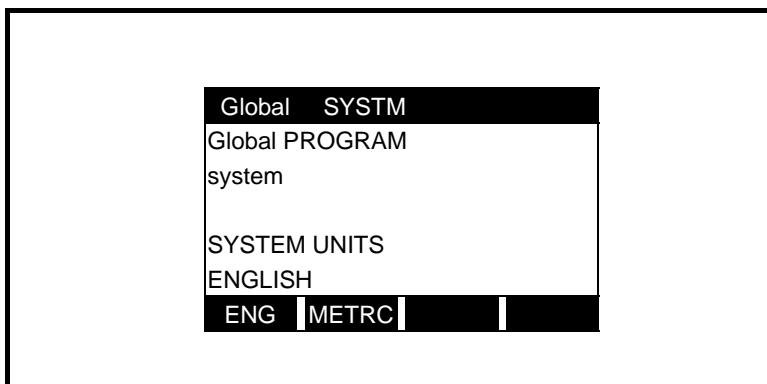
**Figure 3-9:  Screen After Pressing SYSTM Key**

## Entering Global System Parameters (cont.)

### Step 1: Choosing the SYSTM Units

This prompt asks you to choose the SYSTM units that determine whether the TransPort will display subsequent parameters or flow measurements in English or metric units. Use the proper feature key to respond.

- Press [F1] for English Units.

- Press [F2] for Metric Units.

### Step 2: Choosing the Totalizer Option

This prompt lets you specify how channel totals and the stopwatch will function. Enable the Totalizers when you want to time a specific process, average flow over long periods, or perform tests that require you to stop and start the totalized flow manually. When it is set to ON, channel totals and stopwatch time are controlled by the Totalizer/Stop Watch (see Chapter 4, *Totalizer/Stop Watch*, page 4-7 for instructions on how to use the Totalizer/Stop Watch.)

At the Totalizer Option, use the appropriate feature key to respond:

- Press [F1] to turn the Totalizer Option OFF, or

- Press [F2] to turn the Totalizer Option ON.

## Entering Global System Parameters (cont.)

### Step 3: Choosing Volumetric Units

Volumetrics units will display in either English or Metric, depending on which you selected in the Global System Units option (see page 3-37).

To select the measurement units for volumetric flow rate (sum, average, or difference):

**1.** Use the arrow keys to view all the options available. See Table 3-1 on page 3-8 for a list of available volumetric units.

**2.** Press the appropriate feature key to make a selection.

### Step 4: Selecting the Volumetric Decimal Digits

This option enables you to select the number of digits to the right of the decimal for volumetric flow rate (sum, average, or difference). Use the appropriate feature key to choose a number from 0 to 3.

### Step 5: Choosing Totalizer Units

To select the units for totalized flow (sum, average, or difference):

**1.** Use the arrow keys to view all the options available. See Table 3-2 on page 3-9 for a list of available totalizer units.

**2.** Press the appropriate feature key to make a selection.

### Step 6: Selecting the Total Decimal Digits

This option enables you to select the number of digits to the right of the decimal for total flow rate (sum, average, or difference). Use the appropriate feature key to choose a number from 0 to 3.

### Step 7: Choosing Power Units

If you chose to measure energy in either channel, the TransPort will next prompt you to choose the power units (sum, average, or difference). If you chose not to measure energy, the display returns to the Program Channel Menu.

## Entering Global System Parameters (cont.)

To select the units for power:

**1.** Use the arrow keys to view all the options available. See Table 3-3 on page 3-10 for a list of available power units.

**2.** Press the appropriate feature key to make a selection.

**Note:** *The choices available for Global Power Units will depend on the System Units (English or Metric) selected in the Global System Units option (see page 3-37).*

### Step 8: Selecting the Power Decimal Digits
This option enables you to select the number of digits to the right of the decimal for power units (sum, average, or difference). Use the appropriate feature key to choose a number from 0 to 3.

### Step 9: Choosing Energy Units
The next prompt requires you to select the units for energy measurements (sum, average, or difference).

To select the units for energy:

**1.** Use the arrow keys to view all the options available. See Table 3-4 on page 3-11 for a list of available energy units.

**2.** Press the appropriate feature key to make a selection.

**Note:** *The choices available for Global Energy Units will depend on the System Units (English or Metric) selected in the Global System Units option (see page 3-37).*

### Step 10: Selecting the Energy Decimal Digits
This option enables you to select the number of digits to the right of the decimal for energy units (sum, average, or difference). Use the appropriate feature key to choose a number from 0 to 3.

## Entering Global I/O Parameters

The third option in the GLOBL Menu is I/O. This option enables
you to enter information to set up the analog inputs and outputs.
In addition, this option lets you to select how the TransPort will
handle the outputs during error conditions.

To enter the Input/Output option, press [F3]. A screen similar to
Figure 3-10 below appears. Refer to Appendix F, *Menu Maps,*
Figure F-1K for a flow diagram of the I/O options.

```
          Global  I/O
  Global PROGRAM
  Input/output

  Global I/O
  Error handling
  ERROR    IN1     IN2     OUT1
```
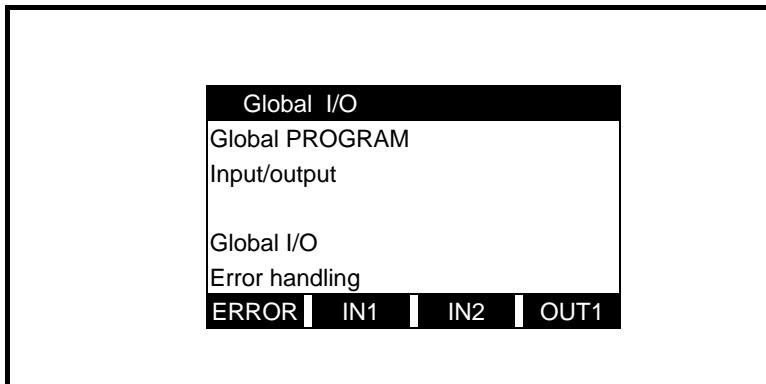
**Figure 3-10:  Screen After Pressing I/O Key**

### Selecting Error Handling

The first prompt asks you to select how the flowmeter will handle
the analog outputs in the event of a fault condition. Use the
appropriate feature key to select one of the following:

• HOLD - holds the last good reading

• LOW - forces the reading low (0 mA or 4 mA)

• HIGH - forces the reading high (20 mA)

## Entering Global I/O Parameters (cont.)

### Setting Up Analog Inputs

The Two-Channel TransPort enables you to set up the analog inputs for Supply and Return temperature for energy flow calculation or for other (user-specified) parameters using a 4 to 20 mA range.

This procedure consists of setting up zero (Base) and span (Full) values for Input 1 and Input 2.

Use the following steps to set up the Supply Input (IN1):

1. If you have not already done so, enter the I/O menu by pressing the [F3] key.

2. Press [F2] to select Input 1.

3. At the next prompt, press the appropriate feature key to respond:

• Press [F1] to turn the analog input off.

• Press [F2] to set up analog input 1 as a live temperature input.

• Press [F3] to set up analog input 1 as a live input for any other (user-defined) parameter.

• If you choose [F2] above, proceed to Step 6. If you choose [F3] above, proceed to Step 4.

4. At this prompt, enter the special parameter name, then press [ENT].

5. Next enter the special parameter units, then press [ENT].

6. At this prompt, enter the Supply Base (4 mA) value, then press [ENT].

7. Next enter the Supply Full (20 mA) value, then press [ENT].

Follow the same procedure to set up the Return Input (IN2).

## Entering Global I/O Parameters (cont.)

**Note:** *If Input 1 is set up as a live temperature input, it is designated as* supply *temperature and can be used by either or both channels for energy measurements. If Input 2 is set up as a live temperature input, it is designated as* return *temperature and can be used by either or both channels for energy measurements.*

### Setting Up Analog Outputs

The next series of prompts in the Input/Output option enable you to set up the analog outputs for Channels 1 and 2 by selecting the units and entering the base and full scale values.

Use the following steps to set up the analog outputs:

1. If you have not already done so, enter the I/O menu by pressing the [F3] key.

2. Press [F4] to select Output 1, or use the arrow keys and press [F1] to select Output 2.

3. At the next prompt, press the appropriate feature key to respond:

- Press [F1] to turn the analog output off.

- Press [F2] to select a 0-20 mA output range, or

- Press [F3] to select a 4-20 mA output range.

4. The next prompt asks you to select the source of the data you want to output. Press the appropriate feature key to make your selection, then press [ENT].

5. At the next prompt, press the appropriate feature key to select one of the following output parameters:

- Velocity

- Volumetric

- Energy (only with the energy option on)

6. Press the appropriate feature key to make your selection.

**Note:** *Units for analog outputs are the same as the units selected in the Global System option.*

## Entering Global I/O Parameters (cont.)

**7.** The next prompt asks you to enter the base (zero) value for the analog output. This value represents the 0 mA/4 mA output (in flow units). Use the numeric keys to enter a value, then press [ENT].

**8.** The next prompt asks you to enter the full scale (span) value for the analog output. This value represents the 20 mA output (in flow units). Use the numeric keys to enter a value, then press [ENT].

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

## Setting Up the RS232 Communications Port

The TransPort can transmit stored data and displayed readings using the RS232 communications port. The TransPort can also receive and execute commands remotely using a serial interface device such as a personal computer.

To use the communications port, make connections as described in Chapter 2, *Initial Setup* (refer to Appendix E for more information on cables). Once you have connected the serial device, you must select the proper settings using the Communication option. The default settings for communications are as follows:

- Baud Rate: 9600

- Word Length: 8 bits

- Parity: None

To change these settings, press [F4]. A screen similar to Figure 3-11 on page 3-45 appears. The indicator box shows you are at the beginning of the Communication option. Refer to Appendix F, *Menu Maps,* Figure F-1L for a flow diagram of the Communication option.

## Setting Up the RS232 Communications Port (cont.)

```
┌─────────────────────────────────────────────┐
│   ┌───────────────────────────────────────┐  │
│   │        Global  COMM  PROGRAM          │  │
│   │ Global PROGRAM                        │  │
│   │ Comm Port                             │  │
│   │                                       │  │
│   │ BAUD RATE                             │  │
│   │ 9600                                  │  │
│   │  4800  │  9600  │  19200  │           │  │
│   └───────────────────────────────────────┘  │
└─────────────────────────────────────────────┘
```
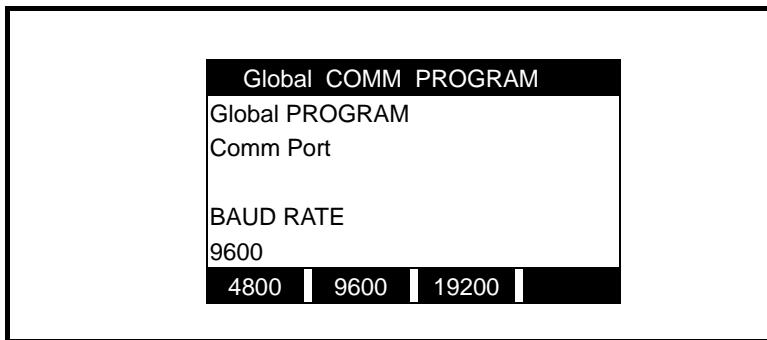
**Figure 3-11:  Screen After Pressing COMM Key**

To set up communications parameters:

**1.** The first prompt asks you to choose the baud rate. Use the arrow keys to view all the options.

**2.** Press the appropriate feature key to select the desired the baud rate.

**3.** The next prompt asks you to enter the UART bits. Use the arrow keys to view all the options.

**4.** Press the appropriate feature key to select the desired data and parity.

## Saving Setup Data

The fourth option in the Program Menu is SAVE, which enables you to save all newly entered setup data in non-volatile memory. The TransPort can store up to 10 sets of setup data simultaneously in a single file.

To enter the SAVE option, press [F4]. A screen similar to Figure 3-12 on page 3-46 appears. Refer to Appendix F, *Menu Maps,* Figure F-1M for a flow diagram of the SAVE option.

# Saving Setup Data (cont.)

```
 Global  SAVE
PROGRAM
SAVE

SITE NAME
SITE
```
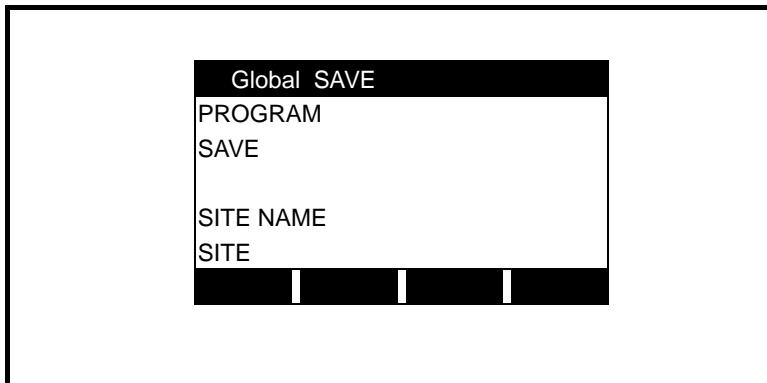
**Figure 3-12:  Screen After Pressing SAVE Key**

If you try to exit the Program Menu without saving the new data, the TransPort will ask, "Do you want to SAVE?" Use the appropriate feature key to respond.

**Note:** *If you do not save the newly entered data before exiting the Program Menu, that data may be lost.*

To save setup data:

**1.** Use the alphanumeric keys to enter a site name (up to five characters) or use a feature key to select a site name to overwrite.

**2.** If you entered a new site name, press [ENT].

Your file is now stored in memory and remains resident until you retrieve another file with the Recall command (see below). To confirm that the file has been stored, use the up arrow key to scroll back to the "SITE NAME"prompt. Notice your file is assigned a feature key. You may have to use the [←] and [→] keys to see your file. Every time you save a file, the TransPort automatically assigns it the next available feature key.

To retrieve a stored file, refer to the following section, *Recalling Files.* To exit the User Program, press [EXIT].

# Recalling Files

The fifth option in the Program Menu is RECLL, which enables
you to retrieve files that you saved earlier.

To enter the RECLL option, use the [←] and [→] keys to scroll
until "RECLL" appears on the screen, then press [F1]. A screen
similar to Figure 3-13 appears. Refer to Appendix F, *Menu Maps,*
Figure F-1N for a flow diagram of the RECLL option.

```
      Global  RECALL
PROGRAM
RECALL

SITE NAME
SITE
  SITE  ▌        ▌      ▌
```
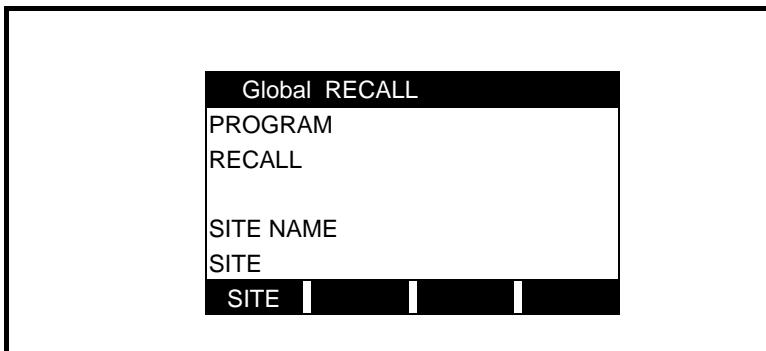
**Figure 3-13:  Screen After Pressing RECLL Key**

To recall a file:

1.  Use the [←] and [→] keys to view all the files available. (Files
    are stored in chronological order.)

2.  Press the appropriate feature key to select the desired file.

The TransPort recalls the file. To exit the Program Menu,  press
[EXIT].

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# Chapter 4

# Displaying Data

The Two-Channel TransPort enables you to display data in
various formats in order to compare and manipulate information.
To enter the Display Menu, press the [DISP] key on the keypad.
A screen similar to Figure 4-1 below appears with the following
six options for displaying data (refer to Appendix F, *Menu Maps*,
Figure F-4 for a flow diagram of the Display Menu):

```
DISPLAY  FEATURES           ➤




DISPLAY FORMAT
Big Single
   BIG    DUAL   GRAPH   LOG
```
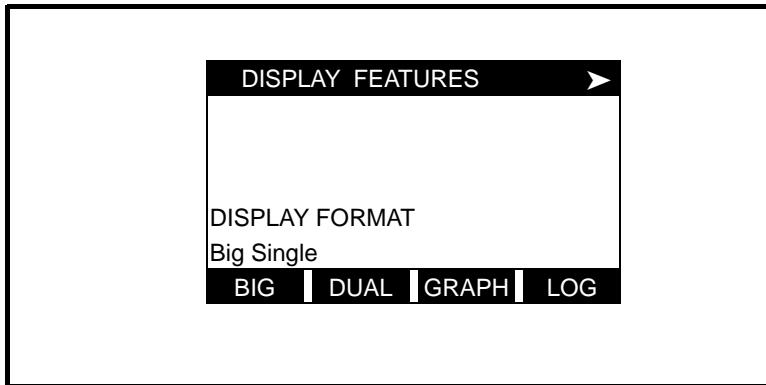
**Figure 4-1:  Display Format Screen**

- Big — shows one measurement at a time (see Figure 4-2 on
  page 4-3).

- Dual — shows two measurements simultaneously (see Figure
  4-3 on page 4-5).

- Graph — shows one measurement at a time on an X/Y type
  line chart (see Figure 4-4 on page 4-9).

- Log — shows up to three logged measurements at a time in
  numeric or graph form (see Figure 4-5 on page 4-11 and Figure
  4-6 on page 4-14).

- Signal — shows a graphical representation of the transducer signal (see Figure 4-7 on page 4-16).

- Backl — lets you enter the number of minutes (from 1 to 60) that you want the display backlight to remain on before it automatically turns itself off (see Figure 4-9 on page 4-21).

Use the appropriate section that follows to display data as desired.

# Big Format

When you first power up, the TransPort automatically displays
data using the Big Format as shown in Figure 4-2 below.
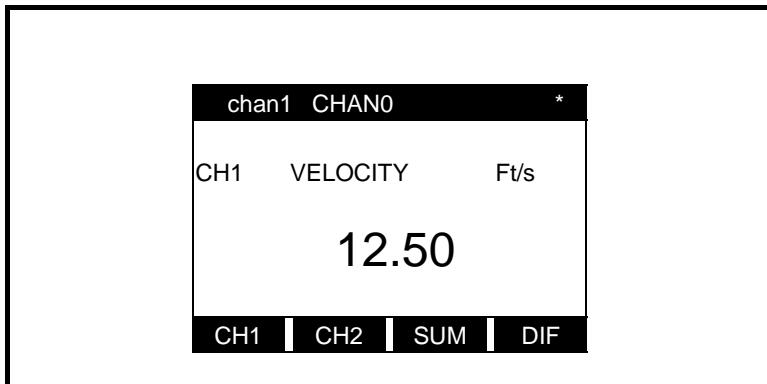


**Figure 4-2:  Big Format**

Use the following steps to return to the Big Format from another
display format.

**1.** Press the [DISP] key.

**2.** Press [F1] to select "BIG."

The TransPort automatically exits the Display Menu and displays
the velocity. If you want to change the measurement displayed,
do the following:

# Big Format (cont.)

**1.** Use the appropriate feature key to select a channel, or the sum, difference, or average of both channels.

**2.** Use the arrow keys to scroll through the following measurement options:

- Velocity

- Volumetric

- Forward Totals

- Reverse Totals

- Time (see *Totalizer/Stop Watch* on page 4-7)

- Power (for energy only)

- Forward Energy (for energy only)

- Reverse Energy (for energy only)

- Diagnostic (refer to "Diagnostics" on page 10-5 for more details)

**3.** Press the appropriate feature key to select a measurement.

# Dual Format

The Dual Format enables you to show two measurements simultaneously, as shown in Figure 4-3 below.

```
  chan1   CHAN0                    *
CH1     FWD ENERGY kBTU
               0
CH2     FWD TOTAL GAL
               0

  CH1  |  CH2  |  SUM  |  DIF
```
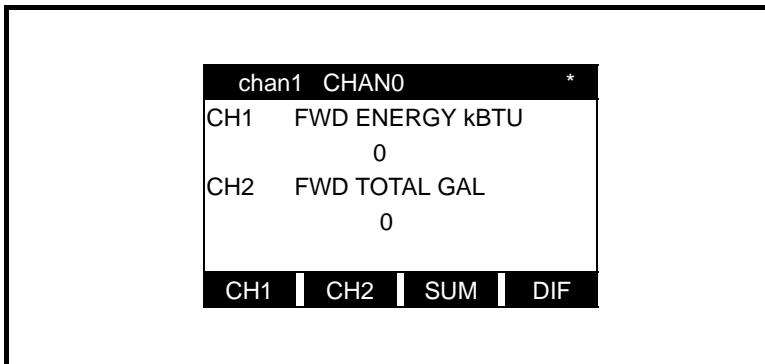
**Figure 4-3:  Dual Format**

Use the following steps to select the Dual Format:

**1.**   Press the [DISP] key.

**2.**   Press [F2] to select "DUAL."

The TransPort automatically exits the Display Menu and displays two measurements. If you want to change the measurement displayed do the following:

# Dual Format (cont.)

**1.** Use the appropriate feature key to select a channel, or the sum, difference, or average of both channels.

**2.** Use the arrow keys to scroll through following measurement options:

- Velocity

- Volumetric

- Forward Totals

- Reverse Totals

- Time (see *Totalizer/Stop Watch* on page 4-7)

- Power (for energy only)

- Forward Energy (for energy only)

- Reverse Energy (for energy only)

- Diagnostic (refer to "Diagnostics" on page 10-5 for more details)

**3.** Press the appropriate feature key to select a measurement.

The newly selected measurement appears on the top line of the screen and the previous measurement is moved to the bottom line of the screen.

# Totalizer/Stop Watch

The Totalizer/Stop Watch can be used for totalizing a specific process, for averaging flow over long periods, or for any testing that requires you to start and stop the totalizing manually. In order to use the Totalizer/Stop Watch, you must have enabled the Totalizer Option when setting up the Global System parameters (see Chapter 3, "Choosing the Totalizer Option," page 3-38). When you enable the Totalizers, the TransPort automatically activates the Totalizer/Stop Watch. Use the Totalizer/Stop Watch to manually start and stop the Totalizers.

## How to Start and Stop the Totalizer/Stop Watch

Use the following instructions to start and stop the Totalizer/Stop Watch and simultaneously start a timer:

- To start the totalizer - simultaneously press and hold down the [ON] and [0] (Ton) keys.

- To stop the totalizer - simultaneously press and hold down the [ON] and [1] (Toff) keys.

**Note:** *The timer and totalizers can be cleared and reset to zero using the [CLR] key (see Chapter 7, "Clearing Totalizers," page 7-2).*

## How to Display Totals

The TransPort can display the totalizer Totals in either the Big or Dual Format. To view the Totals in either format:

1. Press the [DISP] key.

2. Use the appropriate feature key to select "BIG" or "DUAL."

3. Use the appropriate feature key to select a channel, or the sum, difference, or average of both channels.

4. Use the [←] and [→] keys to scroll through the options until the TOTAL option appears, then press [F1]. The Totals are displayed.

**Note:** *The TransPort screen updates approximately once every 2-3 seconds.*

## How to Display Time

The TransPort can display the totalizer time in either the Big or Dual Format. To view the time in either format:

**1.** Press the [DISP] key.

**2.** Use the appropriate feature key to select "BIG" or "DUAL."

**3.** Use the appropriate feature key to select a channel, or the sum, difference, or average of both channels.

**4.** Use the [←] and [→] keys to scroll through the options until the TIME option appears, then press [F1]. The time is displayed.

**Note:** *The TransPort screen updates approximately once every 2-3 seconds.*

# Graph Format

The Graph Format enables you to show velocity or volumetric flow on an X and Y line graph at specified time intervals as shown in Figure 4-4 below. The Graph Format is useful for indicating trends and changes in flow measurements. Use the following sections to set up and use the Graph Format.

```
15.2 GAL/M 09:00          ▶

V
O
L
U
M
    <CURS  CURS>  START   END
```
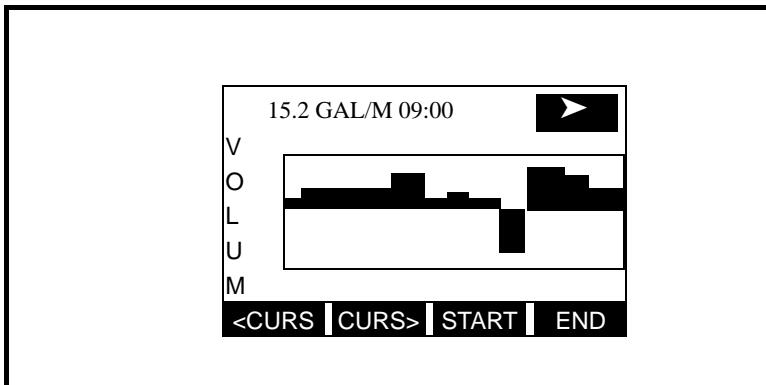
**Figure 4-4:  Graph Format**

## Setting Up the Graph Format

Use the following steps to set up the Graph Format:

1. Press the [DISP] key.

2. Press [F3] to select "GRAPH."

3. Use the appropriate feature key to select a channel, or the sum, difference, or average of both channels.

4. At the next prompt select the "Graph Variable," (the measurement you want to display): velocity, volumetric, or power (for energy only). Use the appropriate feature key to respond.

## Setting Up the Graph Format (cont.)

**5.** At the next prompt select the time increment for the X axis. Use the arrow keys to view the following options:

- 5 seconds

- 10 seconds

- 30 seconds

- 1 minute

- 3 minutes

- 6 minutes

- 12 minutes

**6.** Press the appropriate feature key to make a selection.

**7.** At the next prompt, use the numeric keys to enter a value for the Y (vertical) axis maximum for the graph and press [ENT].

**Note:** *Enter a Y axis value that is larger than the maximum expected flow.*

**8.** At the next prompt, use the appropriate feature key to select either forward only or bi-directional flow for the Y axis.

The TransPort automatically exits the Display Menu and displays the desired measurement in graph form. Use the following section in order to use the graph format.

**Note:** *You may press the [EXIT] key to return to the Big Format.*

## Using the Graph Format

Figure 4-5 below shows an example of a bi-directional flow graph. The Y axis represents the measurement value and the X axis represents time.
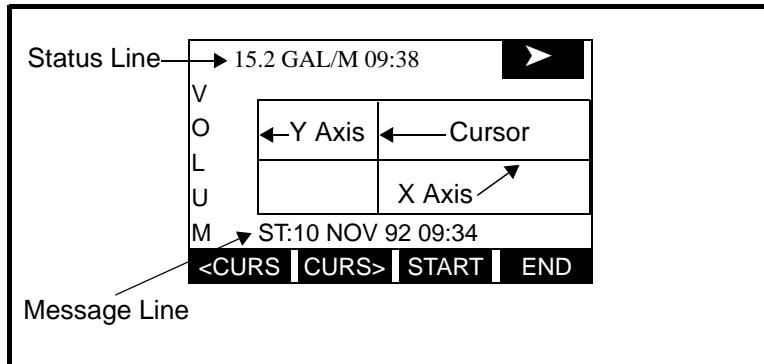


**Figure 4-5:  Bi-directional Graph Format**

**Note:** *For Positive-Only flow graphs, the X axis is the bottom line of the graph.*

The TransPort displays 120 points of data at a time. To view measurement values, use the [<CURS] and [CURS>] feature keys to move the cursor left and right. The Status Line (see Figure 4-5) displays the new measurement value, the units, and the time the measurement was taken. As you cursor over, the measurement value and the time changes.

**Note:** *Since the time displayed on the status line will only show whole minutes, if you selected a time increment of less than 1 minute, the time will not change every time you press the cursor key. For example, if you chose a 5-second increment, you will have to press the cursor key 12 times before the time changes.*

## Using the Graph Format (cont.)

Use the [←] and [→] keys to access the other feature key options for viewing the data in the graph format. Each option is described below:

- START — This feature key automatically moves the cursor to the beginning of the page. In addition, the TransPort displays the start date and time on the message line (see Figure 4-5 on page 4-11).

- END — Contrary to the [START] key , this feature key automatically moves the cursor to the end of the page and displays the end date and time on the message line.

- CHAN — This feature displays the source of the data (CH1, CH2, sum, average, difference) that you selected when setting up the graph (as described on the previous page). The TransPort displays the channel data on the message line.

- YMAX — This feature key displays the Y axis maximum (full scale) chosen when setting up the graph (as described on the previous page). The TransPort displays the Y axis maximum on the message line.

- T INC — This feature key displays the time increment chosen when setting up the graph (as described in the previous section). The TransPort displays the time increment on the message line.

- EXIT — This feature key lets you exit the Graph Format and return to the default Big Format.

**Note:** *To re-enter the graph format after exiting, press the [DISP] key, then "GRAPH" and [EXIT]; you will re-enter the last graph displayed before exiting.*

# Log Format

The Log Format enables you to display logged data graphically or numerically. The TransPort displays all of the data in the log file; however, because of limited space on the screen, the TransPort cannot display all data on the screen simultaneously. Therefore, you must use the feature key options to view the remaining data.

**Note:** *Before viewing a log, you must create a log (see Chapter 6,* Logging Data*).*

Use the appropriate section below to set up and use the graph or numeric format to display logs.

## Displaying Logs in the Numeric Format

**1.** Press the [DISP] key.

**2.** Press [F4] to select "LOG."

**3.** At the next prompt, use the arrow keys to scroll through the log file names.

**4.** Press the appropriate feature key to select the desired file.

**5.** Press [F1] to select "NUM."

The TransPort automatically exits the Display Menu and displays the desired log data in numeric form. Use the following section to view data.

## Using the Numeric Log Format

Figure 4-6 below shows an example of a log displayed in the numeric format. The screen displays the measurement values numerically, including the time and date the measurement was taken. Each set of measurement values is called a record. The TransPort is capable of storing up to 120 pages of records. Each page consists of 120 records. The last line of the screen displays any error messages.
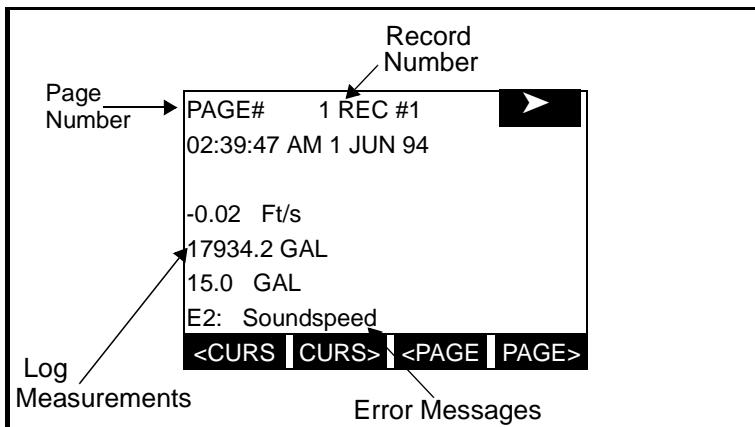


**Figure 4-6: Log Numeric Format**

To view measurement values, use the [<CURS] and [CURS>] feature keys to move from record to record. Use the [<PAGE] and [PAGE>] feature keys to move from one page to the next.

## Displaying Logs in the Graph Format

**1.** Press the [DISP] key.

**2.** Press [F4] to select "LOG."

**3.** At the next prompt, use the [←] and [→] keys to view all the log file names. Use the appropriate feature key to select the desired file.

**4.** Press [F2] to select "PLOT."

**5.** Enter a value for the Y (vertical) axis maximum (full scale) for the graph, then press [ENT].

**Note:** *Enter a Y axis value that is larger than the maximum expected full scale.*

**6.** Use the appropriate feature key to select either forward only or bi-directional flow for the Y axis.

The TransPort automatically exits the Display Menu and displays the desired log data in graph form. Use the following section to view data.

## Using the Graph Log Format

Figure 4-7 below shows an example of a bi-directional log graph. The Y axis represents the measurement value; the X axis represents time.

**Note:** *For Positive-Only flow graphs, the X axis is the bottom line of the graph.*
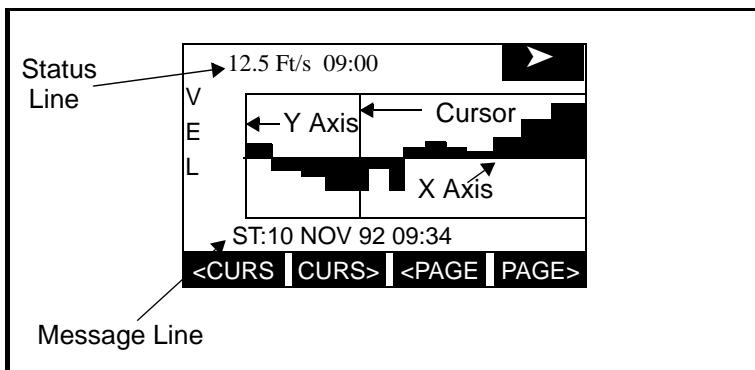


**Figure 4-7: Log Graph Format**

The TransPort displays 120 data points on a page. Each data point represents one measurement taken at the selected logging time interval. Therefore, if you selected a 5-second increment when setting up the log, each page would show 10 minutes of data (5 x 120 = 600 seconds, or 10 minutes).

To view measurement values, use the [<CURS] and [CURS>] feature keys to move the cursor left and right within the current page. When you move the cursor, the Status Line (see Figure 4-7 above) displays the measurement value, units, and the time the measurement was taken. To move quickly, use the [<PAGE] and [PAGE>] feature keys to move from one page to the next.

**Note:** *Since the time displayed on the status line will only show whole minutes and not seconds, if you selected a time increment less than 1 minute, the time will not change every time you press the cursor key. For example, if you chose a 5-second increment, you will have to press the cursor key 12 times before the time changes.*

## Using the Graph Log Format (cont.)

Use the [←] and [→] keys to access the other viewing options. Each option is described below.

- START — This feature key automatically moves the cursor to the beginning of the page. In addition, the TransPort displays the start date and time of that page on the message line (see Figure 4-7).

- END — Conversely, this feature key automatically moves the cursor to the end of the page and displays the end date and time on the message line.

- YMAX — This feature key displays the Y axis maximum (full scale) chosen when setting up the graph (as described in the previous section). The TransPort displays the Y axis maximum on the message line.

- T INC — This feature key displays the time increment chosen when setting up the log (as described in the previous section). The TransPort displays the time increment on the message line.

- EXIT — This feature key lets you exit the Log Format and return to the default Big Format. When you exit to the Big Format, the TransPort displays site measurements, not logged data.

**Note:** *To re-enter the log format on exiting, you must set up the graph as described on page 4-9.*

# Displaying the Signal

The TransPort has a feature in the Display Menu that enables you to graphically display the transducer signal. This is helpful for troubleshooting transducer and other problems.

To display the transducer signal, do the following:

**1.** Press the [DISP] key.

**2.** Press the [←] and [→] keys until "signl" appears, then press [F1].

**3.** Use the appropriate feature key to select the channel you wish to display.

A screen similar to Figure 4-8 below appears. The Y axis represents the amplitude of the signal; the X axis represents the time in microseconds.
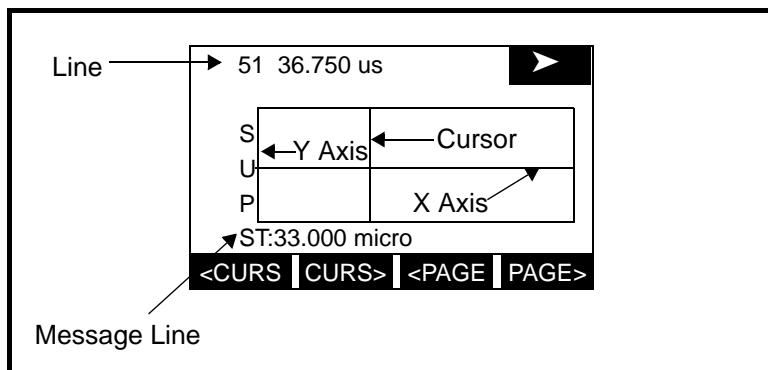


**Figure 4-8:  Signal Format**

## Displaying the Signal (cont.)

To view the signal, use the [<CURS] and [CURS>] feature keys to move the cursor left and right within the current page. Use the [<PAGE] and [PAGE>] feature keys to move quickly from page to page of the signal. When you move the cursor, the Status Line (see Figure 4-8 on page 4-18) displays the signal amplitude and the time.

Use the [←] and [→] keys to access the other viewing options. Each option is described below.

- START — This feature key automatically moves the cursor to the beginning of the page. In addition, the TransPort displays the start date and time of that page on the message line (see Figure 4-8 on page 4-18).

- END — Conversely, this feature key automatically moves the cursor to the end of the page and displays the end date and time of that page on the message line.

- YMAX — This feature key displays the Y axis maximum, which is 512 divisions in arbitrary units. The TransPort displays the Y axis maximum on the message line.

- T INC — This feature key displays the time increment, which is based on the sampling rate (frequency of the transducers). For example, for 1 MHz transducers, it is 0.125 microseconds. The TransPort displays the time increment on the message line.

- EXIT — This feature key lets you exit the Signal Format and return to the default Big Format. When you exit to the Big Format, the TransPort displays site measurements not the signal.

When displaying the signal, the TransPort can display the following:

- Upstream signal (Sup)
- Downstream signal (Sdown)
- Upstream Correlation (Cup)
- Downstream Correlation (Cdown)
- Cross-correlation (CC)

## Displaying the Signal (cont.)

You can toggle between the above displays using the [1] and [2] keys. [1] toggles up, and [2] toggles down. Additionally, [4] vertically enlarges the signal, and [5] reverts it to the original size. [7] horizontally compresses the display, while [8] reverts it to the original size.

**Note:** *To re-enter this format after exiting, you must set up the display again as described on page 4-18.*

# Setting the Backlight Timeout

The Backlight option lets you enter the number of minutes (from 1 to 60) that you want the display backlight to remain on before it automatically turns itself off.

**Note:** *The back light will be disabled if you selected a low transmitter voltage when entering signal limits (see Chapter 3, "Entering Signal Limits," page 3-29.)*

**1.** Press the [DISP] key.

**2.** Press the arrow keys until "BACKL" appears, then press [F2]. A screen similar to Figure 4-9 below appears.

```
DISPLAY FEATURES          ➤
DISPLAY FORMAT
Backlight timeout

Backlight timeout
1                 minutes
```
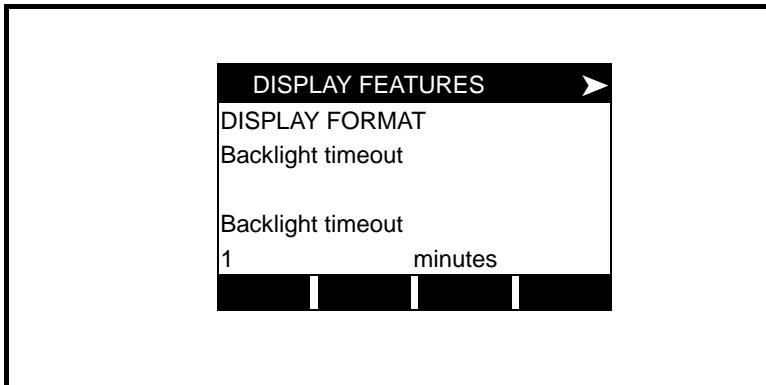
**Figure 4-9: Backlight Timeout Screen**

**3.** Use the numeric keys to enter the amount of time you want the backlight to remain on before it automatically turns itself off.

**4.** Press [ENT].

# Chapter 5

# Printing Data

The Two-Channel TransPort enables you to print various
measurements by connecting a printer to the RS232
communications port. The TransPort is compatible with the
following printers:

- Seiko Instruments Inc. DPU-411 type II Thermal Printer

- Epson printer or printer with compatible command set

- Extech Instruments Mini Serial Printer 42

- Kodak Diconix 150 Plus (with serial interface option)

- Syntest Corporation SP-401 Miniature Thermal Printer

**Note:** *All printers must support a serial port (RS232). If not, use
a serial-to-parallel adapter.*

To access the printer options, press the [PRNT] key. The screen
should appear similar to that shown in Figure 5-1 below.
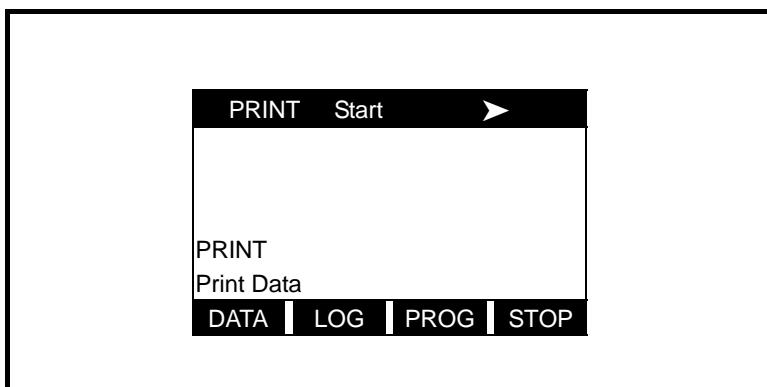


**Figure 5-1: Printer Screen**

Refer to Appendix F, *Menu Maps,* Figure F-2 for a flow diagram of the Print Menu. The Printer Menu consists of the following options:

- DATA — prints "live" measurements in user-specified time increments.

- LOG — prints logged data in either numeric or graphic format.

- PROG — prints site location parameter files (as described in Chapter 3, *Programming Site Data*).

- STOP — stops the printing function.

- PRNTR — enables you to select printer types.

In order to print, you must set up the printer as described below. Once you have set up the printer, use the sections that follow to print out the desired data.

## Setting Up the Printer

To print, connect the printer to the RS232 communications port as described in Chapter 2, *Initial Setup.* Once the printer is connected, use the following steps to select the printer type (refer to Appendix F, *Menu Maps*, Figure F-2E for a flow diagram of the PRiNTeR option):

1. Press [PRNT]. A screen similar to Figure 5-1 on page 5-1 appears.
2. Use the arrow keys to scroll through the options until "PRNTR" appears.
3. Press [F1] to select "PRNTR."
4. At the next prompt, press the appropriate feature key to select the type of printer you are using.

You have completed setting up the printer. Use the following sections to print the desired data.

# Printing "Live" Measurements

The Two-Channel TransPort enables you to print "live" measurements. This means that the measurements displayed on the screen can also be printed either numerically or plotted on a graph in user-specified time increments. Examples of numeric and graphic outputs are shown in Figures 5-2 (on page 5-7) and 5-3 (on page 5-8).

**Note:** *Measurements will be printed in the system units chosen in the Program Menu SYSTeM option. Do not make changes to the system units after printing has begun.*

To print "live" measurements (refer to Appendix F, *Menu Maps*, Figure F-2A for a flow diagram of the DATA option):

1. Access the Printer Menu by pressing the [PRNT] key.

2. Press [F1] to select "DATA."

3. At the next prompt, select whether you want to print data numerically or plot the data on a graph. Use the appropriate key to respond.

4.

   - If you choose "NUM," the next three pairs of prompts (1st, 2nd, & 3rd value printed) ask you to enter the channel and then the measurement value you want. Press the appropriate feature keys at each prompt, then proceed to Step 7.

   - If you choose "PLOT," the next prompt asks for the channel and the measurement value to be plotted. Press the appropriate feature keys, then proceed to Step 5.

5. At the next prompt enter the maximum value for the Y (vertical) axis (full scale). Enter a Y axis value larger than the maximum expected Y excursion. Use the numeric keys to enter a value and press [ENT].

## Printing "Live" Measurements (cont.)

**6.** At the next prompt enter the Y range to display forward-only or bi-directional flow. Use the appropriate key to select plus only or bi-directional.

**7.** At the next prompt enter the time increments to print. Use the arrow keys to view all the options, then press the appropriate feature key to make a selection.

The TransPort begins printing at the selected time increment. The TransPort will continue to print page by page until you tell it to stop, which is described on page 5-6, "To Stop Printing."

## Printing Logged Data

The TransPort enables you to print previously logged data in numerical or plot form. Examples of numeric and graphic outputs are shown in Figures 5-2 (on page 5-7) and 5-4 (on page 5-9).

To print logged data (refer to Appendix F, *Menu Maps*, Figure F-2B for a flow diagram of the LOG option):

**1.** Access the Printer Menu by pressing the [PRNT] key.

**2.** Press [F2] to select "LOG."

**3.** Select whether you want to print data numerically or plot the data on a graph. Use the appropriate key to respond.

**4.** Select the log you want to print. Use the arrow keys to view all the file names, then press the appropriate key to make a selection.

**5.** If you choose "NUM" in Step 3, the TransPort begins printing. If you choose "PLOT," the next prompt asks you to enter the maximum value for the Y (vertical) axis. Use the numeric keys to enter a value, then press [ENT]. Enter a Y axis value that is larger than the maximum expected Y excursion.

# Printing Logged Data (cont.)

**6.** The next prompt asks you to enter the Y range to display forward or bi-directional flow. Use the appropriate key to select either +only, or bi-directional.

The TransPort will begin printing the log when you exit the Print Menu. To stop printing, refer to page 5-6, "To Stop Printing."

# Printing Site Data

The TransPort enables you to print the site data that you entered into the user program (as described in Chapter 3, *Programming Site Data*). An example of printed site data is shown in Figure 5-5 on page 5-11.

To print site data (refer to Appendix F, *Menu Maps,* Figure F-2C for a flow diagram of the PROGram option):

**1.** Access the Printer Menu by pressing the [PRNT] key.

**2.** Press [F3] to select "PROG."

**3.** Select the file you want to print. Use the arrow keys to view all the file names, then press the appropriate key to make a selection.

The TransPort immediately begins printing the file when you exit the Print Menu. To stop printing, refer to the next section, "To Stop Printing."

# To Stop Printing

You may stop printing at any time by doing the following (refer to Appendix F, *Menu Maps,* Figure F-2D for a flow diagram of the STOP option):

**1.** Access the Printer Menu by pressing the [PRNT] key.

**2.** Press [F4] to select "STOP."

**3.** At the next prompt, do one of the following:

- Press [F1] to continue to print and exit the Print Menu.

- Press [F2] to stop printing and exit the Print Menu.

Once you issue the STOP command, the printer will continue to print the data that remains in the printer buffer. If your printer has a large buffer, you can either wait for the printer to complete printing, or turn the printer off to empty the buffer.

# Examples of Printed Data

The following figures show examples of how data appears after it is printed. Printouts may vary depending on the printer you are using. Figure 5-2 below shows an generic example of a plot output.
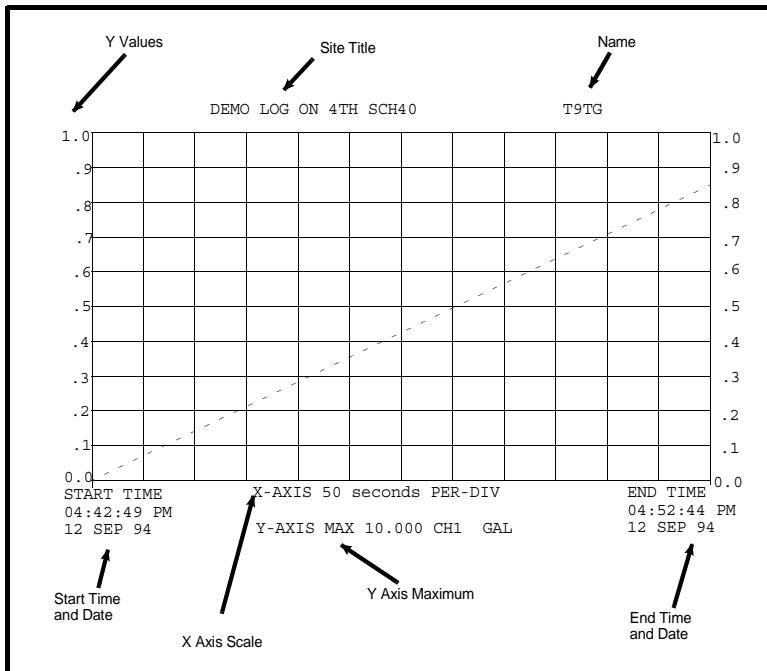


**Figure 5-2:  An Example of a Plot Output
for Live or Logged Data**

The TransPort prints the log or channel message and name on the top of the graph.The start time and date are located in the bottom left corner and the end time and date are shown in the bottom right corner. Finally, the X axis scale and the Y axis maximum areshown on the bottom of the graph in the center.

# Examples of Printed Data (cont.)

Figure 5-3 below shows an example of a numeric output for live data. The first line indicates the type of output you are printing. Below that, the channel labels and messages, as well as the start date and start time of the data dump are listed. The measurement time and measurements are listed in columns below. In this example the selected time increment was 5 seconds.

```
                 Output Type

                                    Channel  Message
  DATA DUMP of TEST1
  chan1 SITE1 FIRST SITE
  chan2 SITE2 SECOND SITE
                                       Start Date
  Start Date
                             05 DEC 94
  Start Time                 04:06:15 PM
                                      Start Time

              CH1       CH2       AVE
              VOLUM     VOLUM     VOLUM
  HH:MM:SS    GAL/M     GAL/M     GAL/M
  04:06:15 P  0.89      0.77          1
  04:06:21 P  0.89      0.77          1
  04:06:25 P  0.89      0.77          1

  04:06:30 P  0.89      0.77          1
  04:06:35 P  0.89      0.77          1
  04:06:40 P  0.89      0.77          1
  04:06:45 P  0.89      0.77          1
  04:06:50 P  0.89      0.77          1
  04:06:55 P  0.89      0.77          1


                              Measurements
                              and Units

     Measurement Time
```

**Figure 5-3:  An Example of a Numeric Output for Live Data**

# Examples of Printed Data (cont.)

Figure 5-4 below shows an example of a numeric output for logged data. The first line indicates the type of output you are printing. The TransPort then prints the log name and page number. The page number corresponds to the pages on the TransPort screen. A new page is started for each 120 points. Following these two lines, the TransPort prints the log message, start date and time, and end date and time. Then the TransPort begins printing the specified logged data at the specified time intervals.

**Note:** *This example shows only a portion of a printed page.*

```
                        Log Name
     LOG DUMP                  Page Number
     TSTG Page #1
      DEMO LOG ON 4IN SC40       Log Message
                                         Start Time and Date
     Start Date
                           12 SEP 94
     Start Time            04:42:49 PM
     End Date              12 SEP 94
     End Time              04:52:44 PM
                                          End Time
                                          and Date
  Logged Data         CH1       CH2       SUM
                     +TOTL     +TOTL     +TOTL
     HH:MM:SS         GAL       GAL       GAL
     04:42:49 P 0.000     0.000     0
     04:42:54 P 0.000     0.077     0
     04:42:59 P 0.046     0.077     0

     04:43:04 P 0.046     0.183     0
     04:43:09 P 0.093     0.183     0
     04:43:14 P 0.093     0.277     0
     04:43:19 P 0.139     0.371     1
     04:43:24 P 0.231     0.558     2
     04:43:29 P 0.322     0.651     2
     04:43:34 P 0.367     0.838     2
     04:43:39 P 0.458     0.932     2
     04:43:44 P 0.504     1.118     2
     04:43:49 P 0.595     1.306     2
     04:43:54 P 0.686     1.399     3
```

**Figure 5-4: An Example of a Numeric Output for Logged Data**

# Examples of Printed Data (cont.)

Figure 5-5 on the following page is an example of a numeric output for site data. The first line indicates the type of output you are printing. The TransPort then prints the channel label and message, followed by the system, pipe, input/output, setup, Global, and communication parameters.

Output Type

Channel Name

PROGRAM PARAMETERS:    TEST

CHAN SYSTEM PARAMETERS:

Channel Message

Channel
System
Parameters

```
 Energy Option        Off
 chan1 SITE: FIRST SITE
 Volumetric Units     gal/min
 VOL Decimal Digits   0
 Totalizer Units      gallons
 TOT Decimal Digits   0
```

Pipe
Parameters

```
PIPE PARAMETERS
 Transducer number       41
 Pipe OD                 0.500 inches
 Pipe Wall               0.050 inches
 Path Length             9.28 inches
 Axial Dimension L       9.00 inches
 Fluid Type              Water
 Water                   Normal water
 Water Temperature       68.000 deg F
 Reynolds correction     On
 Kinematic viscosity     10.000 E-6 ft 2/s
 Calibration Factor      1.000
```

Input/Output
Parameters

```
CHAN I/O PARAMETERS
 Zero Cutoff             0.020 Ft/s
```

Setup
Parameters

```
SETUP PARAMETERS
SIGNAL
 Signal Low Limit     40
 Signal High Limit    85
 Corr. Peak Limit     100
 Soundspeed +-Limit   20 percent
 Velocity Low Limit   -40.000 Ft/s
 Velocity High Limit  40.000 Ft/s
 Acceleration Limit   15.000 Ft/s
 Amp Discrim Low      14
 Amp Discrim High     34
 Delta T Offset       0.0 nsec
 % Peak               -40 percent
 Transmit Voltage     High Voltage
 Xmit Sample Size     0
AVERAGE
 Response Time        STATISTICS
TOTAL
 Totalizer Option     Off
```

Global
System
Parameters

```
GLOBAL SYSTEM PARAMETERS
 System Units         ENGLISH
 Volumetric Units     gal/min
 VOL Decimal Digits   0
 Totalizer Units      gallons
 TOT Decimal Digits   0
```

Input/Output
Parameters

```
GLOBAL I/O PARAMETERS
ERROR:
 Error Handling       Hold Last Value
 Analog Input 1       Off
 Analog Input 2       Off
 Analog Out #1        Off
 Analog Out #2        Off
```

Communication
Parameters

```
COMMUNICATIONS PARAMETERS
 Baud Rate            9600
 UART bits            8 data, no parity
```

**Figure 5-5:  An Example of a Site Data Print Out**

# Chapter 6

# Logging Data

A powerful and flexible feature of the Two-Channel TransPort is data logging. The TransPort lets you log up to six sets of parameters. You can also select the log start time and date, end time and date, and time interval. Logs can run one at a time or simultaneously.

Logged data is internally stored in battery backed-up memory. The TransPort stores logged data in as many as 120 pages of memory allocated for data logging. Each page can hold up to 120 records. The TransPort assigns each page a header, and uses the header to distinguish one page from another. The header contains the log name, start time and date, end time and date, log parameters, and the selected time interval (these parameters are selected in the Log Menu in the PARAM option). Each record contains three parameters, as well as the log name, start and end times, and the time interval. For example, if you choose to log velocity, forward totals, and reverse totals every 5 minutes, at each 5 minute interval the values for the selected parameters represent one record.

**Note:** *Each log uses at least one page. Pages cannot be shared by logs.*

Since data logging contains only a fixed amount of memory, the frequency of the time interval, the length of the log run, and the number of logs you choose affect the amount of memory. For example, a log that records every 5 seconds will use more memory than a log that records every 5 minutes for a given amount of time.

Once you make your data logging selections, the TransPort lets you to view the amount of memory left. You may also stop logging or view logged data while or after data is logged as described in Chapter 4, *Displaying Data*.

This section describes:

- How to enter the Log Menu.

- How to set up the data logger.

- How to view the data logger memory.

- How to stop logging.

# Entering the Log Menu

To access the Log Menu, press the [LOG] key. A screen similar to Figure 6-1 below appears. The indicator box shows that you are at the beginning of the Log Menu. Refer to Appendix F, *Menu Maps,* Figure F-3 for a flow diagram of the LOG Menu.

```
┌──────────────────────────────────┐
│ LOG                    Start      │
│                                   │
│                                   │
│ LOGGING                           │
│ Name, Mess., Units, Time          │
│ PARAM  MEM   STOP                 │
└──────────────────────────────────┘
```
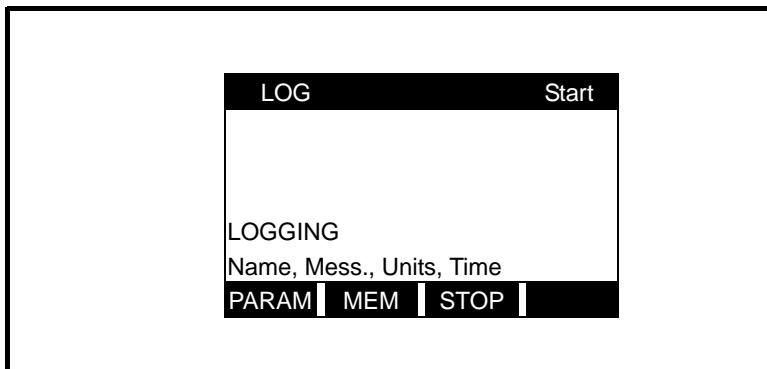
**Figure 6-1:  Screen After Pressing the LOG Key**

The Log Menu consists of the following options:

- PARAM — enables you to enter parameters for the data logger.

- MEM — enables you to view how much memory is available and how much memory is needed for the current programmed logs.

- STOP — enables you to stop logging data.

Use the appropriate section that follows to set up and use the data logger.

# Entering Data Log Parameters

The first option in the Log Menu is PARAM. This option enables you to select the log parameters such as the measurements to log, how frequently to log them, and when to begin and end logging.

To enter PARAM, press [F1]. A screen similar to Figure 6-2 below should appear. The indicator box shows that you are at the beginning of this option.



```
   NAME, MESSAGE, etc.
LOGGING
Name, Mess., Units, Time


NAME

```
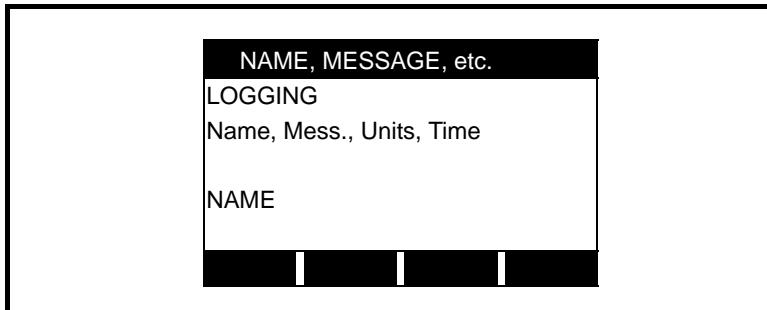
**Figure 6-2:  Screen After Pressing the PARAM Key**

Once you enter this option the following prompts appear:

- Name

- Log Message

- 1st Value Logged

- 2nd Value Logged

- 3rd Value Logged

- Set Log Totals To Zero (if totals was selected)

- Start Time

- Start Date

- End Time

- End Date

- Time Increment

# Entering Data Log Parameters (cont.)

Use the steps that follow to enter the data logger parameters:

### Step 1: Entering a Log Name

At this prompt you have two choices, you may enter a new log name or choose to overwrite an existing log.

- To set up a new log enter, use the alphanumeric keys to enter a file name (up to five characters) and press [ENT].

- To view or alter an existing log, use the arrow keys to scroll through the log names, then press the appropriate feature key to make a selection.

### Step 2: Entering a Log Message

Enter a brief description (up to 21 characters) of the log. This message, in conjunction with the log name, helps you distinguish one log from another.

### Step 3: Entering the Log Values

The next three prompts (1st, 2nd, & 3rd value logged) ask you to enter the channels (or sum, difference, or average) and the measurements you want to log. Press the appropriate feature keys at each prompt.

### Step 4: Setting the Log Totals

If you chose totals as one of the measurement values to be logged, the next prompt asks if you want to set the log totals to zero when the log begins; otherwise, logged totals begin at the current totalizer value. Press the appropriate feature key to make your selection.

### Step 5: Entering the Log Start Time

This prompt asks you to enter the time you want to begin logging. To accept the displayed time, press [F1] and proceed to Step 6. To start the log immediately, press [F3] and proceed to Step 7. To enter a new time do the following:

**1.** Press [F2] to edit the start time.

**2.** Press the appropriate feature key to select AM or PM.

# Entering Data Log Parameters (cont.)

**3.** Use the numeric keys to enter the hour.

**4.** Press [ENT].

**5.** Use the numeric key to enter the minutes.

**6.** Press [ENT].

**7.** Use the numeric keys to enter the seconds.

**8.** Press [ENT].

The TransPort proceeds to the next prompt.

### Step 6: Entering the Log Start Date

The next prompt asks you to enter the date you want to begin logging. To accept the displayed date, press [F1] and proceed to Step 7. To start the log today, press [F3]. To enter a new date, do the following:

**1.** Press [F2] to edit the start date.

**2.** Use the numeric keys to enter the year.

**3.** Press [ENT].

**4.** Use the arrow keys to scroll through the options, then press the appropriate feature key to select the desired month.

**5.** Use the numeric keys to enter the day.

**6.** Press [ENT].

The TransPort proceeds to the next prompt.

### Step 7: Entering the Log End Time

The next prompt asks you to enter the time you want to end the log. To accept the current end time press [F1] and proceed to Step 8. To set a new end time or to stop the log in a specified period of time (such as in 10 minutes) use one of the following sections.

**Note:** *The log end time must exceed the start time by at least 5 minutes.*

# Entering Data Log Parameters (cont.)

To enter a new end time:

**1.** Press [F2] to edit the end time.

**2.** Press the appropriate feature key to select AM or PM.

**3.** Use the numeric keys to enter the hour.

**4.** Press [ENT].

**5.** Use the numeric key to enter the minutes.

**6.** Press [ENT].

**7.** Use the numeric keys to enter the seconds.

**8.** Press [ENT].

The TransPort proceeds to the next prompt. Proceed to Step 8 to complete entering the log parameters.

To end the log in a specified period of time:

**1.** Press [F3] to select "TIMED."

**2.** Use the arrow keys to scroll through the selections, then press the appropriate feature key to select a log time.

Proceed to Step 8 to complete entering the log parameters.

**Note:** *The longer the log runs the more memory it uses.*

### Step 8: Entering the Log End Date
The next prompt asks you to enter the date you want to end logging. To accept the displayed date, press [F1]. To end the log today, press [F3]. To enter a new date do the following:

**1.** Press [F2] to edit the end date.

**2.** Use the numeric keys to enter the year.

**3.** Press [ENT].

# Entering Data Log Parameters (cont.)

**4.** Use the arrow keys to scroll through the options, then press the appropriate feature key to select the desired month.

**5.** Use the numeric keys to enter the day.

**6.** Press [ENT].

The TransPort proceeds to the next prompt.

**Note:** *The longer the log runs, the more memory it uses.*

### Step 9: Selecting the Time Increment
At this prompt select the time between each log update. Use the arrow keys to scroll through the options, then press the appropriate feature keys to select the desired time increment.

**Note:** *The more frequently you update the log, the more memory it uses.*

This completes the log parameter entry. The TransPort returns to the beginning of the Log Menu. At this time, proceed to the following section to see if there is enough memory available to store the parameters you want to log.

To exit press the [EXIT] key. The "*" in the indicator box indicates the TransPort is currently logging.

# Checking the Data Logger Memory

It is important to check the availability of logger memory after setting up a log to see if the amount of data you want to log exceeds the amount of available memory. To check the memory, do the following:

**1.** If you have not already done so, access the Log Menu by pressing the [LOG] key.

**2.** Press [F2] to select memory.

The screen displays the number of pages available out of 120 pages (see Figure 6-3 below). In addition, the number of pages pending is also shown. The pages pending is the amount of memory that will be used by all programmed logs.



```
        LOG MEMORY LEFT          *
LOGGING
Memory

118/120 Pages FREE
7 Pages PENDING
```
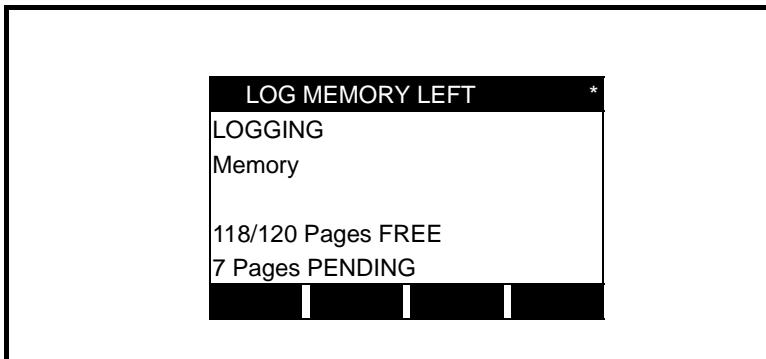
**Figure 6-3:  Viewing Data Logger Memory**

If the amount of memory pending exceeds the available memory, you must either clear old logs as described in Chapter 7, *Clearing Data*, or return to the previous section, "Entering Data Logger Parameters," and switch to a less frequent time increment and/or shorten the log time.

**3.** When you are finished viewing, press [ENT].

The TransPort returns to the beginning of the Log Menu. To exit, press [EXIT].

## Checking the Data Logger Memory (cont.)

Use the following formula to figure out how many pages a log will use:

length of log × no. of readings/unit time = no. of records
then,
no. of records ÷ 120 = no. of pages

For example, if you select a log to run for 24 hours with a time increment of 1 minute, this log will use 12 pages of memory because:

$$24 \times 60 = 1440 \text{ records}$$
$$1440 \div 120 = 12 \text{ pages}$$

## Stopping a Log

To stop a log, do the following:

**1.** Access the Log Menu by pressing the [LOG] key.

**2.** Press [F3] to select "STOP."

**3.** At the next prompt, use the arrow keys to scroll through the available logs, then press the appropriate feature key to select the log you want.

**4.** At the next prompt, do one of the following:

- Press [F1] to continue to log and exit the Log Menu.

- Press [F2] to stop logging and exit to the Log Menu.

To exit the Log Menu, press [EXIT].

# Chapter 7

# Clearing Data

The Two-Channel TransPort has a Clear Menu that enables you to delete old logs, delete setup files, and reset totalizers. To clear channel data, press the [CLR] key. A screen similar to Figure 7-1 below appears. The indicator box shows you are at the beginning of the Clear Menu. Refer to Appendix F, *Menu Maps*, Figure F-5 for a flow diagram of the Clear Menu.
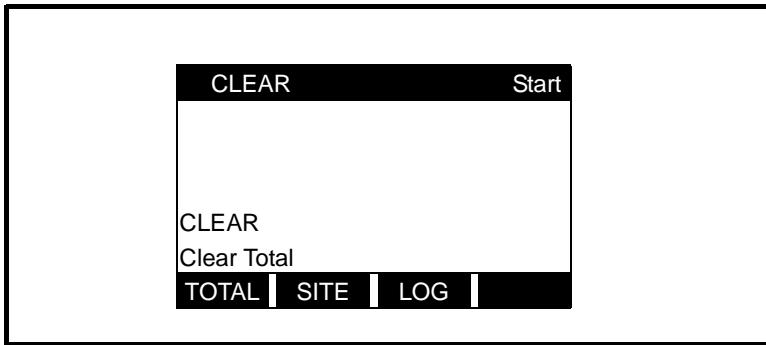


**Figure 7-1: Screen After Pressing the CLR Key**

The Clear Menu has three options:

- Total (Clears totalizers)

- Site

- Log

Use the appropriate section that follows to clear the desired parameters.

## Clearing Totalizers Totals

To clear totals:

1.  Press [F1] to choose "TOTAL."

2.  Use the appropriate feature key to select the channel total you want to clear.

3.  At the next prompt, use the appropriate feature key to respond.

    • Press [F1] if you do not want to clear totals.

    • Press [F2] to clear totals and reset the Totalizer/Stop Watch to zero.

The TransPort automatically returns to making measurements.

## Clearing Site Files

To clear site files:

1.  Press [F2] to select "SITE."

2.  Use the arrow keys to scroll through the file names, then press the appropriate feature key to select the file you want.

3.  At the next prompt, use the appropriate feature key to respond:

    • Press [F1] if you do not want to clear the selected site parameter file.

    • Press [F2] to clear the site parameter file.

If you have one or more site files left, the TransPort returns to the beginning of the Clear Site option. At this point you may clear another file, or press the [EXIT] key to return to making measurements.

# Clearing Logs

To clear logs:

**1.** Press [F3] to select "LOG."

**2.** Use the arrow keys to scroll through the file names, then press the appropriate feature key to select the log file you want to clear.

**3.** At the next prompt, use the appropriate feature key to respond:

- Press [F1] if you do not want to clear the log.

- Press [F2] to clear the log.

If you have one or more logs left, the TransPort returns to the beginning of the Clear Log option. At this point you may clear another log or press the [EXIT] key to return to making measurements.

# Chapter 8

# Calibrating Analog Outputs and Inputs

To calibrate the Two-Channel Transport's analog outputs and inputs, or to use the optional ultrasonic thickness gage, you must enter the Calibration Menu by pressing the [CAL] key. When you enter the Calibration Menu, a screen similar to Figure 8-1 below appears. The Calibration Menu has three options (refer to Appendix F, *Menu Maps*, Figure F-6 for a flow diagram of Calibration Menu):

- A/OUT - enables you to calibrate the analog outputs.

- A/IN - enables you to calibrate the analog inputs.

- WALL - enables you to calibrate and use the optional ultrasonic thickness gage. Refer to Chapter 9, *Using the Ultrasonic Thickness Gauge.*

```
 CALIBRATION



CALIBRATE
cal analog output
A/OUT    A/IN    WALL
```
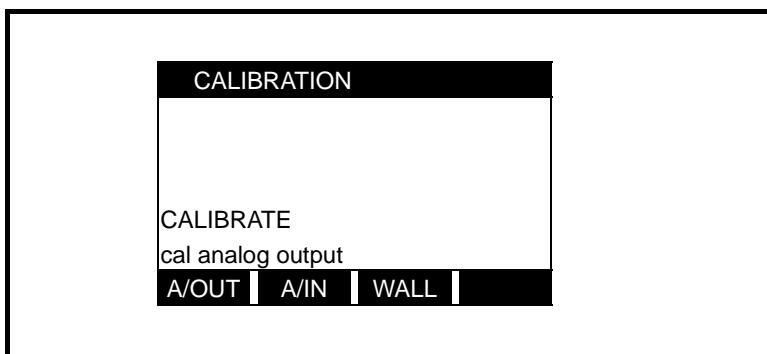
**Figure 8-1:  Screen After Pressing CAL Key**

This chapter discusses how to calibrate the analog outputs and inputs only. Use the appropriate section that follows in order to calibrate the desired output.

# Analog Output

To calibrate the 4-20 or 0-20 mA outputs, you need to connect a multimeter or ammeter to the analog output connector as shown in Figure 8-2 below (refer to page 2-3 for more information for connecting the analog outputs).

The calibration procedure consists of calibrating the analog outputs zero and full scale for both Output 1 and Output 2 as described in the following steps. The resolution of the analog outputs is 5.0 mA (0.03% full scale).
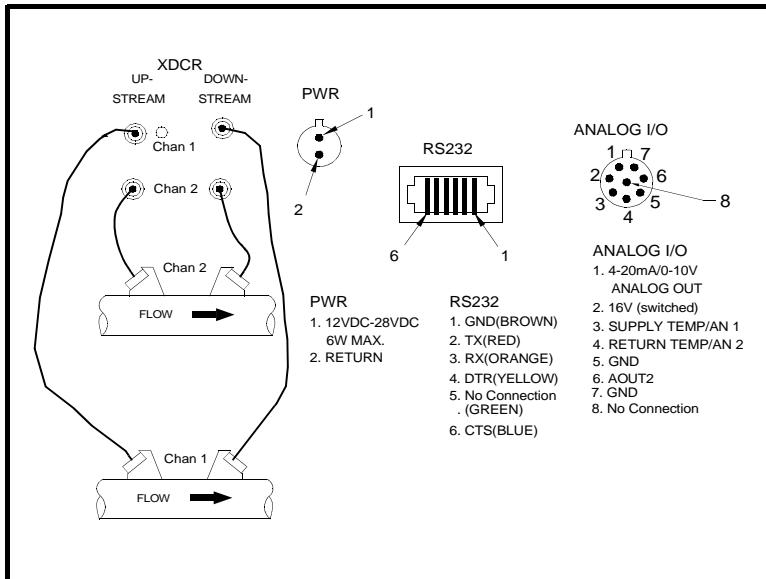


**Figure 8-2:  Analog Output Connections**

# Analog Output (cont.)

To calibrate the analog outputs:

**4.** Access the Calibration Menu by pressing the [CAL] key.

**5.** Press [F1] to select "A/OUT".

**6.** Next, press [F1] to select "4 mA." You must calibrate the low end to 4 mA regardless of the type of output you are using. (If you are using a 0-20 mA output, the TransPort extrapolates the 0 mA point from the 4 mA calibration.)

**7.** At the next prompt, press the appropriate feature key to select which output you want to calibrate to 4 mA.

**8.** Check the mA reading on the multimeter or ammeter. It should read close to 4 mA. If it does not, use one of the following keys to adjust the reading to 4 mA.

   • Press [F1] to adjust the reading up

   • Press [F2] to adjust the reading down

**Note:** *If you cannot adjust the readings close enough to 4 mA, contact the factory.*

**9.** When you have adjusted the reading to 4 mA, press [F3] to select "O.K."

**10.** At the next prompt press [F2] to select "20 mA."

**11.** Press the appropriate feature key to select the output you want to calibrate to 20 mA.

**12.** Check the mA reading on the multimeter or ammeter. It should read close to 20 mA. If it does not, use one of the following keys to adjust the reading to 20 mA.

   • Press [F1] to adjust the reading up or

   • Press [F2] to adjust the reading down.

**Note:** *If you cannot adjust the readings close enough to 20 mA, contact Panametrics.*

## Analog Output (cont.)

**13.** When you have adjusted the reading to 20 mA, press [F3] to select "O.K."

**14.** At the next prompt, press the appropriate feature key to select the next output you want to calibrate to 4 mA.

**15.** Repeat steps 5 through 10 to make necessary adjustments, then press the [EXIT] key.

You have completed calibrating the analog outputs. At this time you may do one of the following:

- If you have finished calibrating, press the [EXIT] key and then [F3] to exit the Calibration Menu.

- If you want to calibrate temperature inputs, press [F3] and refer to the next section for instructions.

# Analog Inputs

The Two-Channel TransPort allows you to calibrate the analog inputs using an external reference. To calibrate the analog inputs, you must connect a low and high temperature reference or a calibrated current source to the analog input connector as shown in Figure 8-3 below.
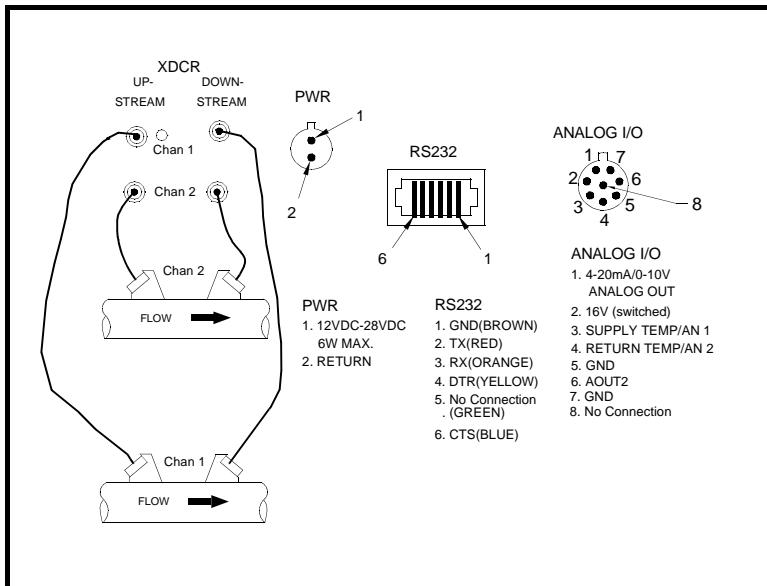


**Figure 8-3:  Analog Input Connections**

The calibration procedure consists of calibrating the low and high values for the supply and then the low and high values for the return. Use the sections that follow to properly calibrate the TransPort.

**Note:** *The two analog inputs may be calibrated in any order.*

## Low and High Calibration for Supply

Use the following steps to calibrate the supply:

### *Calibrating the Low Supply*

1. Connect the low temperature reference (or current source) to the temperature input for supply (see Figure 8-3 on page 8-5).

2. If you have not already done so, enter the Calibration Menu by pressing the [CAL] key.

3. Press [F2] to select "A/IN."

4. Depending on your calibration reference, press [F1] to select "LOW" or [F3] to select "4mA."

5.
    - If you select "LOW," enter the low temperature reference value (in either °F or °C depending on the units selected), then press [ENT] and proceed to Step 6.

    - If you select "4 mA," use the appropriate feature key at the next prompt to select which input you want to calibrate to 4 mA, then proceed to Step 7.

6. Press [F1] to select "SPPLY."

7. Press [F1] to calibrate the supply lead. The TransPort shows the low reference value on the screen.

8. Press [F2] to exit.

## *Calibrating the High Supply*

1. Connect the high temperature reference (or current source) to the temperature input for supply (see Figure 8-3 on page 8-5).

2. Depending on your calibration reference, press [F2] to select "HIGH" or [F4] to select "20mA."

3.

   - If you select "HIGH," enter the high temperature reference value (in either °F or °C depending on the units selected), then press [ENT] and proceed to Step 4.

   - If you select "20 mA," use the appropriate feature key at the next prompt to select which input you want to calibrate to 20 mA, then proceed to Step 5.

4. Press [F1] to select "SPPLY."

5. Press [F1] to calibrate the supply lead. The TransPort shows the high reference value on the screen.

6. Press [F2] to exit.

## Low and High Calibration for Return

Use the following steps to calibrate the return.

### *Calibrating the Low Return*

**1.** Connect the low temperature reference (or current source) to the temperature input for return (see Figure 8-3 on page 8-5).

**2.** Depending on your calibration reference, press [F1] to select "LOW" or [F3] to select "4mA."

**3.**

- If you selected "LOW," enter the low temperature reference value (in either °F or °C depending on the units selected), then press [ENT] and proceed to Step 4.

- If you select "4 mA," use the appropriate feature key at the next prompt to select which input you want to calibrate to 4 mA, then proceed to Step 5.

**4.** Press [F2] to select "RTN."

**5.** Press [F1] to calibrate the return lead. The TransPort shows the low reference value on the screen.

**6.** Press [F2] to exit.

*Calibrating Analog Outputs and Inputs*

## *Calibrating the High Return*

**1.** Connect the high temperature reference (or current source) to the temperature input for return (see Figure 8-3 on page 8-5).

**2.** Depending on your calibration reference, press [F2] to select "HIGH" or [F3] to select "20mA."

**3.**

- If you selected "HIGH," enter the high temperature reference value (in either °F or °C depending on the units selected), then press [ENT] and proceed to Step 4.

- If you select "20 mA," use the appropriate feature key at the next prompt to select which input you want to calibrate to 20 mA, then proceed to Step 5.

**4.** Press [F2] to select "RTN."

**5.** Press [F1] to calibrate the return lead. The TransPort shows the high reference value on the screen.

**6.** Press [F2] to exit.

**Note:** *If you cannot adjust the low and high reading for supply and return, repeat the procedures. If you still cannot successfully calibrate contact the factory.*

You have completed calibrating the temperature inputs. At this time you may do one of the following:

- If you are finished calibrating inputs/outputs, press [EXIT] twice and the TransPort begins taking measurements.

- If you want to calibrate the analog output, press [EXIT] and refer to page 8-2 for instructions.

*To reconnect the analog outputs and temperature inputs, refer to Chapter 2,* Initial Setup.

# Chapter 9

# Using the Ultrasonic Thickness Gauge

The TransPort can measure thickness when equipped with the optional ultrasonic thickness transducer (supplied separately). The ultrasonic thickness transducer connects to the transducer connectors. The internal thickness gauge not only measures the thickness of a pipe, but it can also measure the sound speed of a substance if the thickness is known.

The thickness gauge is factory calibrated and programmed. You do not need to calibrate or re-program the thickness gauge unless you receive new transducers or have a reason to question readings.

Use the following sections and refer to Appendix F, *Menu Maps,* Figures F-6 & F-7 to set up, calibrate, and program the ultrasonic thickness gauge.

See Appendix G for the theory of operation and application notes for the thickness gauge.

# Connecting the Ultrasonic Thickness Transducer

Plug the ultrasonic thickness transducer into the transducer connectors located on the top of the TransPort (see Figure 9-1). Note that the transducer cable plug must be oriented with the center pin down.
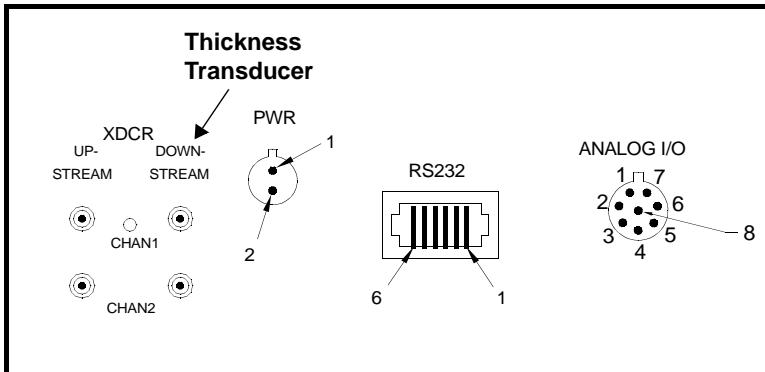


**Figure 9-1:  Ultrasonic Thickness Transducer Connections**

---

**!WARNING!**
**WHEN UNPLUGGING THE TRANSDUCER, PULL ON THE MOLDED PLUG ONLY. DO NOT PULL ON THE CABLE.**

---

# Measuring Pipe Thickness

The TransPort displays thickness measurements numerically. You may also view the signal and thickness measurements graphically.

The graph format displays the signal for as long as you hold the transducer to the pipe. The graph format also has a special feature that enables you to find the signal zero crossing used to calculate the thickness. Use the following sections to make thickness measurements.

## Making Measurements

To measure the pipe wall thickness:

**1.** Enter the Calibration Menu by pressing the [CAL] key; then press [F3] to select "WALL." A screen similar to Figure 9-2 below should appear.

```
         THICKNESS GAUGE
THICKNESS                    inches




GRAPH   MAT'L   SNDSP
```
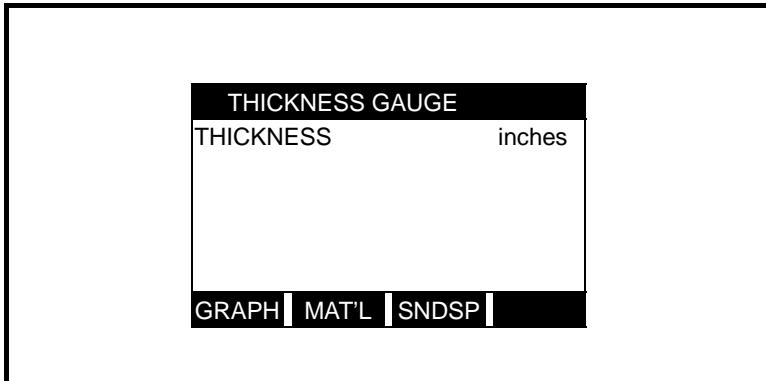
**Figure 9-2:  Ultrasonic Gauge Thickness Screen**

**2.** Press [F2] to select "MAT'L."

## Making Measurements (cont.)

**3.** Use the arrow keys to view all the selections for pipe material. Use the appropriate feature key to make a selection. If your pipe material is not listed, choose the "OTHER" option and enter the longitudinal sound speed of the pipe material. Appendix B contains a list of common pipe materials and the corresponding longitudinal sound speeds. If you know the length of the material you are measuring, you can measure the sound speed with the thickness gauge as described on page 9-5.

**Note:** *The TransPort may prompt you for additional information depending on your selection. Use the appropriate feature key to respond.*

**4.** Apply couplant to the pipe at the spot where you will be making the measurement. In general, the smoother the pipe surface, the thinner the couplant should be applied. Rough surfaces require a more viscous couplant, such as a gel or a grease. Special couplants are required for high temperature applications.

**5.** Place the tip of the transducer on the pipe surface over the couplant. Use moderate to firm pressure and keep the transducer face as flat as possible. The line on the transducer face should be positioned perpendicular to the pipe axis as shown in Figure 9-3 below.
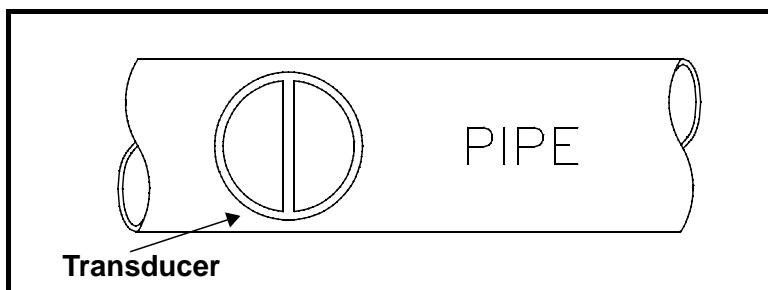


**Figure 9-3: Proper Alignment of Thickness Transducer on Cylindrical Surfaces**

The TransPort displays thickness readings numerically . Use the following section to view readings graphically.

## Measuring the Sound Speed

The Thickness Gauge is capable of measuring the sound speed of a material if the thickness of the material is known (at a flange for example). Use the steps below to measure the sound speed:

**1.** Enter the Calibration Menu by pressing the [CAL] key; then press [F3] to select "WALL." A screen similar to Figure 9-4 below should appear.

```
         THICKNESS GAUGE
THICKNESS                 inches




 GRAPH  MAT'L  SNDSP
```
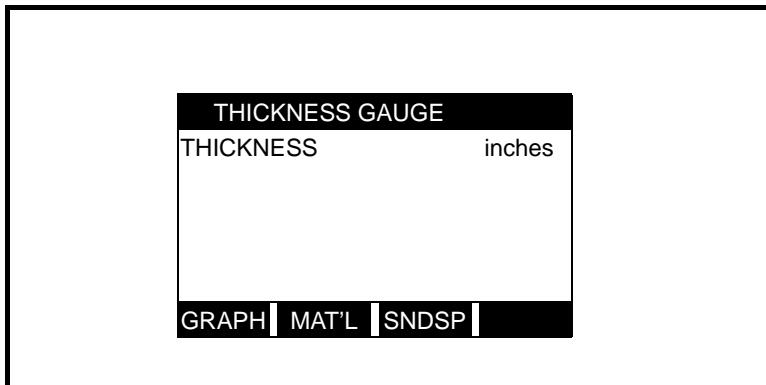
**Figure 9-4:  Ultrasonic Thickness Gauge Screen**

**2.** Press [F3] to select "SNDSP."

**3.** Use the numeric keys to enter the length (thickness) of the sample material and press [ENT]. The TransPort displays the sound speed.

**4.** To exit, press [F1].

## Graphically Displaying Thickness Transducer Signal

To troubleshoot the unit or verify thickness readings, the TransPort enables you to view the thickness transducer signal. To display the thickness gage signal, press the [F1] key to select "GRAPH."

**Note:** *If you are not in the Calibration Menu, press the following keys: [CAL]; [F3] to select "WALL"; [F1] to select "GRAPH."*

Figure 9-5 shows an example of thickness signal. The Y axis represents the amplitude of the signal (in arbitrary units). The X axis represents the time expressed as samples. A sample is taken every 31.25 nsec (32MHz). The message line displays the start time (in µsec) of the current page and the measured thickness of the pipe.
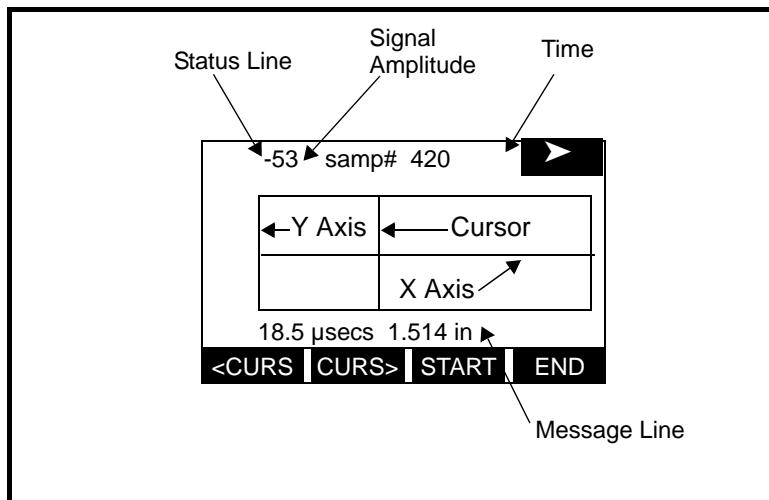


**Figure 9-5: Graph Format for Thickness Measurements**

The TransPort displays 120 samples per page. Since there is a limited amount of space to display readings, use the feature key options to view the remaining data.

## Graphically Displaying Thickness Transducer Signal (cont.)

The following options are available (use the arrow keys to view all the options):

- [<CURS] and [CURS>] keys - to move one sample at a time.

- [<PAGE] and [PAGE>] keys - to pan an entire page. Each page is 3.75 msec.

- [FIND] key - moves the cursor to the zero crossing, which is used to calculate the sample thickness.

**Note:** *Depending on the thickness of the pipe material, you may not get a signal on the first page. Press the [PAGE>] key until the signal appears, or press the [FIND] key once.*

# Calibrating the Thickness Gauge

The ultrasonic thickness gauge is factory calibrated; therefore, you only need to perform calibration if you receive new transducers or have a reason to doubt the accuracy of the readings.

To calibrate you will need the following:

- a test block, which is shipped with the thickness transducer (or test block of known sound speed and length)
- ultrasonic couplant

To calibrate the thickness gauge, you must enter the Calibration Menu and then enter the appropriate data.

## Entering the Calibration Menu

**1.** Press the [CAL] key to enter the Calibration Menu.

**2.** At the next prompt press [F3] to select "WALL."

**3.** Press the [CAL] key.

## Entering Calibration Data

**1.** Use the numeric keys to enter either one of the test block lengths; then press [ENT]. If you are using a Panametrics supplied test block, the length is printed on the block.

**2.** Use the numeric keys to enter the other test block length; then press [ENT]. If you are using a Panametrics supplied test block, the length is printed on the block.

**Note:** *To perform a one point calibration, enter the same number for both lengths.*

# Calibrating the Thickness Gauge (cont.)

**3.** The TransPort displays one of the test block lengths. This is the end you should use to calibrate first. Apply couplant to the appropriate end of the test block and place the thickness transducer on the block. The transducer face should be flat against the surface of the test block.

**4.** The screen should display approximately the correct thickness of the test block. Press the [F1] key to select "CAL." The TransPort locks in the calibration.

**5.** Repeat steps 3 and 4 for the other end of the test block.

**6.** Press [F2] (or [EXIT]) to exit.

The TransPort returns to the thickness gauge display. You are now ready to make pipe thickness measurements.

If you do not wish to make thickness measurements, press the [EXIT] key until the TransPort returns to making flow measurements.

# Programming the Ultrasonic Thickness Gauge

Once you access the thickness gage option, the TransPort converts from an ultrasonic flowmeter to an ultrasonic thickness gauge. The thickness gauge has a Program Menu that enables you to view or change the following parameters:

- Low Signal Threshold

- Detection Threshold

- Transducer Delay

- System Units

- Gain Level

- Signal Inversion

The thickness gauge settings are entered at the factory. You should not change them unless instructed by the factory. The only setting you may change without affecting the thickness gauge operation is the system units.

To enter the thickness gauge Program Menu, do the following:

1. If you have not already, enter the Calibration Menu by pressing the [CAL] key.

2. Press [F3] to select "WALL."

3. Press the [PROG] key.

A screen similar to the one shown in Figure 9-6 on page 9-11 appears. The indicator box shows you are at the beginning of the Program Menu for the ultrasonic thickness gauge.

---

*If you only want to change the System Units, press the [ENT] key until the "System Units" prompt appears; then follow the instructions in the corresponding section.*

---

## Programming the Ultrasonic Thickness Gauge (cont.)

```
┌─────────────────────────────────┐
│  PROGRAM              Start      │
│                                  │
│                                  │
│  LOW SIGNAL THRESHOLD            │
│  45                              │
│                                  │
│   ▌      ▌     ▌                 │
└─────────────────────────────────┘
```
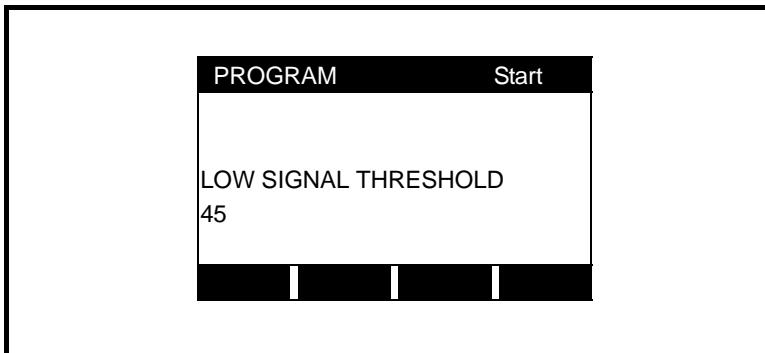
**Figure 9-6:  Thickness Gauge Program Screen**

### Low Signal Threshold

This parameter sets the signal strength alarm. If the signal strength falls below this value, a "Low Signal" message appears on the screen. This number should be set to 45 unless otherwise instructed by the factory. To change this number:

**1.** Use the numeric keys to enter the new number.

**2.** Press [ENT].

The TransPort proceeds to the next prompt.

### Detection Threshold

This number represents the percent of peak the TransPort uses to make measurements. The TransPort will consider anything above the entered percentage as part of the signal. Consult the factory before changing this number. If you are instructed to change this number, use the steps below:

**1.** Use the numeric keys to enter the new number.

**2.** Press [ENT].

The TransPort proceeds to the next prompt.

## Transducer Delay

This number represents the time the ultrasonic signal takes to travel from the TransPort to the pipe material surface. This number should be set to 7.0 microseconds unless otherwise instructed by the factory. To change this number:

1. Use the numeric keys to enter the new number.

2. Press [ENT].

The TransPort proceeds to the next prompt.

## System Units

The fourth prompt in the Thickness Gauge Program Menu is System Units. These units are identical to the system units in the Flowmeter Program Menu; however, these system units apply to the thickness gauge. This is the only parameter you should change without consulting the factory.

To change the System Units, use one of the following keys to respond:

- Press [F1] for English units, or

- Press [F2] for Metric units.

The TransPort automatically proceeds to the next prompt.

## Signal Inversion

This prompt enables you to invert the thickness transducer signal. This option should be on unless otherwise instructed. Signal inversion may be required if your thickness readings are showing excessive jitter or for certain unusual combinations of pipe and fluid or pipe and lining. Consult the factory before measuring the thickness of lined pipes. Also, when measuring the thickness of certain pipe materials (Teflon in particular), it may be necessary to drain the pipe before measuring the pipe wall, because certain pipe/liquid combinations muffle the ultrasonic echo.

## Signal Inversion (cont.)

To change the signal inversion status, use one of the following keys:

- Press [F1] to turn the signal inversion ON or

- Press [F2] to turn the signal inversion OFF.

To exit the Thickness Gauge Program Menu, press [EXIT].

## Gain Level

This prompt enables you to change the gain level of the signal. The gain level is set at the factory and should not need to be reset; however, if you are instructed to change the gain level, do the following:

- Press [F1] for Low Gain, or

- Press [F2] for High Gain.

# Chapter 10

# Diagnostics and Troubleshooting

The TransPort is a reliable instrument that is easy to maintain. It will provide accurate flow measurement readings as long as it is operated as described in this manual. If problems do arise with the electronics, transducers or the flowcell, the TransPort displays an error message specifying the possible problem. The TransPort also has a set of diagnostic parameters to help you find and remedy the problem.

In general, troubleshooting may be necessary if the TransPort displays an error message, the flow readings are erratic, or you have other reasons to doubt the accuracy of readings (for example, readings do not agree with other flow measuring devices connected to the same process).

This section describes error messages, diagnostic parameters, and shows you how to isolate problems to one of the following areas:

- Electronics, including programmed values

- Flowcell, which includes the pipe and fluid

- Transducers and cables.

# Error Code Messages

Error Code messages appear on the screen while you are displaying measurements. Error Codes do not appear when you are displaying measurements in graph form, or when displaying logged data. The Error Code messages are only general descriptions of the possible problems. Use Table 10-1 on pages 10-3 and 10-4 to isolate and remedy the problem. If you are unable to remedy the problem, contact Panametrics.

**Note:** *We suggest that, in order to isolate the indicated problem more easily, you obtain a test flowcell. Contact Panametrics.*

## Table 10-1: Error Messages

| Error Message | Problem | Possible Cause | Action |
|---|---|---|---|
| E0 | No error. | Displays briefly after the display of another error message | None required. |
| E1 | Low Signal - Poor ultrasonic signal strength. | Broken cable. Flowcell problem. Transducer problem. Electronic failure. | Check transducer cable. See Flowcell Problems on page 10-8 and Transducer Problems on page 10-11. Check programming and transducer spacing. Contact the factory if problem persists. |
| E2 | Sound Speed Error (Sound speed is programmed using the Program Menu PIPE option as described in Chapter 3.) | Poor flow conditions. Incorrect programming. Bad transducer spacing. Measurement is very different from the programmed sound speed. | Check sound speed against nominal sound speed (See Appendix B). See Flowcell Problems on page 10-8 and Transducer Problems on page 10-11. Check programming and transducer spacing |
| E3 | Velocity Range - Velocity exceeds programmed limits. (Velocity limit is programmed using the Program Menu SETUP option as described in Chapter 3.) | Programming error, poor flow conditions, or bad transducer spacing. | Make sure flow rate is within ±12 m/s (±40 ft/s). Check programming and transducer spacing. If programmed value is outside of limit, change the limits as described in Chapter 3 on pages 3-27 and 3-28. See Flowcell Problems on page 10-8 and Transducer Problems on page 10-11 |

## Table 10-1:  Error Messages (Continued)

| Error Message | Problem | Possible Cause | Action |
|---|---|---|---|
| E4 | Signal Quality | If too high - electronic failure. If too low - flowcell, electrical problem. | Check for source of electrical interference. Check electronics with a test flowcell. If unit still fails to operate, contact the factory. |
| E5 | Amplitude Error | Excessive particles or bubbles present in fluid. A lot of second phase present. | See Flowcell Problems on page 10-8. |
| E6 | Cycle skip, Acceleration | Poor flow conditions or bad transducer spacing. | Check transducer spacing as programmed and as set on pipe.  See Flowcell Problems on page 10-8 and Transducer Problems on  page 10-11. |
| E7 | Analog Out Error | Under current output. | Check that output load is within specification <550 ohm. |
| E8 | Temperature Input Supply/ IN1 | Supply temperature input out of range. | Check cable and transmitter. |
| E9 | Temperature Input Return/ IN2 | Return temperature input out of range. | Check cable and transmitter. |

# Displaying Diagnostic Parameters

The TransPort provides a Diagnostic Menu to aid in troubleshooting in the event of flowcell, transducer, or electrical problems.

**Note:** *The TransPort must be displaying measurements in the Big Format as discussed in Chapter 4,* Displaying Data, *page 4-3, to view diagnostic parameters.*

You can enter the Diagnostic Menu two ways:

- Choose CH1, CH2, SUM, DIF, or AVE for which you want diagnostics.

- Use the right arrow key until "DIAG" appears; then press [F1] to select, or

- Press the [EXIT] key while in Dual or Big Display mode.

Use the arrow keys to view all the options; then press the appropriate feature key to make a selection. The diagnostic parameter is displayed on the screen until you choose another feature key option. Table 10-2 on pages 10-6 and 10-7 shows all the available diagnostic parameters and ranges.

You can exit the Diagnostic Menu two ways:

- Use the arrow keys until "EXIT" appears; then press [F4] to select, or

- Press the [EXIT] key.

## Table 10-2: Diagnostic Parameters

| Diagnostic Parameter | Displays | Good | Bad |
|---|---|---|---|
| SS up | Displays the signal strength for the upstream transducer. | 50-80 | <50 |
| SS do | Displays the signal strength for the downstream transducer. | 50-80 | <50 |
| SNDSP | Displays the measured sound speed of the fluid. | Check longitudinal sound speed of fluid in Appendix B. | |
| Tup | Displays the upstream transit time of the ultrasonic signal in micro seconds | N/A | N/A |
| Tdown | Displays the downstream transit time of the ultrasonic signal in μseconds. | N/A | N/A |
| DELTA | Displays Delta T (the difference between the upstream and down-stream transit times). | N/A | Continuous large fluctua-tions of 1 μsecond or more. |
| REYN# | Displays the Reynolds Number. | N/A | N/A |
| K(RE) | Displays the K Factor, based on the Reynolds Number. | N/A | N/A |
| PEAK% | Displays the Percent of Peak. Set to -40 by default. To change, see Chapter 3, page 3-32. | N/A | N/A |
| THETA | Displays the THETA 3 angle, cal-culated from the measured transit time and the clamp-on parame-ters. THETA 3 is the angle between the ultrasonic beam and the normal to the pipe wall (clamp-ons only). | N/A | N/A |
| Qup | Displays the signal quality for the upstream transducer. | ±300 or higher | between ±100 |
| Qdown | Displays the signal quality for the downstream transducer. | ±300 or higher | between ±100 |
| AMPup | Displays the value for the ampli-tude discriminator of the upstream transducer. | 20-28 | less than 20 or greater than 28. |
| AMPdn | Displays the value for the ampli-tude discriminator of the down-stream transducer. | 20-28 fluctua-tions | less than 20 or greater than 28 fluctuations |
| P#up | Displays signal peaks for the upstream transducer. | 100-900 | <100 >900 |

## Table 10-2: Diagnostic Parameters (Continued)

| Diagnostic Parameter | Displays | Good | Bad |
|---|---|---|---|
| P#dn | Displays signal peaks for the downstream transducer. | 100-900 | <100 >900 |
| NFup | Displays the normalization factor for the upstream transducer. | 0.85 - 1.0 | <0.85 |
| NFdn | Displays the normalization factor for the downstream transducer. | 0.85 - 1.0 | <0.85 |
| Cxdcr | Displays the velocity of sound in the transducer (clamp-on only). | N/A | N/A |
| TEMPs | Displays the temperature for the supply input (energy measurement). | N/A | N/A |
| TEMPr | Displays the temperature for the return input (energy measurement). | N/A | N/A |
| Ts-Tr | Displays the difference between supply and return temperature | N/A | N/A |
| DENSs | Displays the density for the supply input. (Energy measurement.) | N/A | N/A |
| DENSr | Displays the density for the return input. (Energy measurement.) | N/A | N/A |
| DELTh | Displays the delta enthalpy, or difference between the supply and return enthalpy (enthalpy is a measure of energy contained in the fluid.) (Energy measurement.) | N/A | N/A |
| "OTHER"1 | Displays the value of analog input 1 if "other" is selected (Global/IN1/OTHER). | N/A | N/A |
| "OTHER"2 | Displays the value of analog input 2 if "other" is selected (Global/IN1/OTHER). | N/A | N/A |

# Flowcell Problems

Flowcell problems fall into two categories: fluid problems and pipe problems. Read the following sections carefully to determine if such problems exist.

## Fluid Problems

Most fluid-related problems can be solved by proper design of the flowmeter installation and the proper choice of transducer frequency. Contact Panametrics if you cannot solve a fluid-related problem.

Certain fluid properties may prevent proper flow measurement. Some fluid properties that cause problems are listed below.

1.  THE FLUID MUST BE HOMOGENOUS, SINGLE PHASE, RELATIVELY CLEAN, and FLOWING STEADILY. Solid particles and gas bubbles absorb and disperse ultrasound. Although, in some cases, solids and gases have little effect on the operation of the TransPort, excessive amounts will prevent ultrasound transmission through the fluid and interfere with proper flow measurement. Temperature gradients may also cause a problem.

2.  THE FLUID MUST NOT CAVITATE NEAR THE FLOWCELL. Fluids with a high vapor pressure may cavitate near or in the flowcell. This causes problems resulting from gas bubbles in the fluid. Cavitation can usually be controlled through proper installation design.

3.  THE FLUID MUST NOT ATTENUATE ULTRASOUND EXCESSIVELY. Some fluids, particularly those that are very viscous, absorb ultrasound energy. In these cases an "E1" will display on the screen to indicate that the ultrasonic signal is not of sufficient strength for reliable measurements.

## Fluid Problems (cont.)

**4.** THE FLUID SOUND SPEED MUST NOT VARY EXCESSIVELY. The TransPort will tolerate relatively wide, but slow, changes in fluid sound speed due to changes in fluid composition and temperature. However, if you are measuring a fluid that is considerably different from the fluid programmed into the TransPort, you may have to adjust the meter for the new fluid. Refer to Chapter 3, "Entering Pipe Parameters" on page 3-12.

## Pipe Problems

Improper pipe conditions and/or flowcell installation can cause problems with measurement of the fluid flow. Check the items below if you suspect this class of problem. Contact Panametrics if you cannot solve pipe-related problems.

**1.** THE INSIDE OF THE PIPE OR FLOWCELL MUST BE RELATIVELY CLEAN. Excessive build up of scale, rust, or debris will interfere with flow measurement. Generally, a thin coating or a solid well-adhered buildup on the pipe wall will not cause problems. Loose scale and thick coatings (such as tar or oil) will interfere with ultrasound transmission and may result in incorrect or unreliable measurements.

**2.** THE FLOWCELL ORIENTATION MUST NOT ALLOW SEDIMENT OR GAS ENTRAPMENT AT THE TRANSDUCER LOCATIONS. Sediment or gas trapped in the transducer ports for wetted transducers, or at the transducer locations for clamp-on transducers, will interfere with flow measurement. Realignment of the flowcell or transducers often cures these problems. In some cases, different transducers may be used that protrude into the flow stream.

## Pipe Problems (cont.)

**3.** THE PIPE OR FLOWCELL DIMENSIONS MUST BE ACCURATE. The accuracy of your flow measurements will be no better than the accuracy of your programmed pipe or flowcell dimensions. If PANAMETRICS did not supply your flowcell, the dimensions you program must be consistent with the required flow accuracy. Check your pipe for wall thickness, diameter, dents, eccentricity, weld deformity, and straightness.

**4.** THE PIPE SURFACES SHOULD BE SMOOTH (FOR CLAMP-ON). When using clamp-on transducers, both the inside and the outside of the pipe at the transducer locations must be smooth. If the pipe is extremely rough, the ultrasonic signal will be scattered by the rough surface, and will not be received by the flowmeter, preventing flow measurement.

**5.** THE PIPE MUST ALLOW ULTRASOUND TO PASS THROUGH (FOR CLAMP-ON). Some pipe materials or linings, such as fiberglass (or generic fiber reinforced pipe), Teflon, and polyethylene, absorb ultrasound and may cause problems in clamp-on applications. Pipes with extremely thick walls or high OD to ID ratios may also present difficulties.

# Transducer Problems

Ultrasonic transducers are rugged; however, they are subject to physical damage due to mishandling and chemical attack. Clamp-on transducers are also subject to installation variables, such as physical misalignment and faulty coupling to the pipe on which they are mounted.

Because transducer problems are largely dependent on the type of transducer used, wetted or clamp-on, the following list of potential problems is grouped according to transducer type. Contact Panametrics if you cannot solve a transducer-related problem.

## Wetted Transducer Problems

1. **LEAKS**
   Leaks may occur around the transducer and in the fittings of the flowcell. Repair as you would any other leak. Check the transducer and cables for damage if the leaking fluid is corrosive.

2. **CORROSION DAMAGE**
   Wetted transducers may be damaged by corrosive fluids if the transducer material does not match the application. Most often, corrosion damage occurs at the electrical connector. To check for damage, remove the transducer from the flowcell. If the wetted end of the transducer is rough and pitted, the transducer may have to be replaced. Panametrics can supply suitable transducer materials for most fluids. Contact Panametrics for information on special transducers.

3. **INTERNAL DAMAGE**
   An ultrasonic transducer consists of a ceramic "crystal" bonded to the transducer case. The bond between the crystal and the case may be damaged by extreme mechanical shock and by temperature extremes. The crystal itself can also be damaged by the same conditions. The internal wiring can be corroded or shorted if contaminants enter the transducer housing.

## Wetted Transducer Problems (cont.)

**4.** PHYSICAL DAMAGE

Transducers may be physically damaged by dropping them onto a hard surface or striking them against another object. Usually the connector on the transducer is the part that is damaged, as it is the most fragile. Minor damage may be repaired by carefully bending the connector back into shape. If the connector cannot be repaired, replace the transducers. Note that transducers must be replaced in pairs. Before replacement, make sure that the transducer number in the programmed parameters is the one engraved on the new transducers (see Chapter 3, *Programming Site Data*).

## Clamp-on Transducer Problems

**1.** POOR COUPLING TO PIPE

Clamp-on transducers must be in intimate contact with the pipe. The pipe wall must be smooth and generally free of paint. The couplant material must fill voids between the transducer and the pipe, and must be firmly coupled or bonded to both the pipe and the transducer. The pipe and transducer must be clean and dry for permanent couplant, such as grease or epoxy, to adhere properly. Enough pressure must be applied to the transducer by its clamp to hold it firmly against the pipe.

**2.** MISALIGNMENT

The transducer transmits relatively narrow beams of ultrasound, and therefore transducer alignment is critical to assure that the beam can travel from one transducer to the other without undue attenuation. Be sure to exactly follow the instructions that came with your transducers and clamping fixtures. Also, be sure that the transducer spacing agrees with the calculated spacing (S).

## Clamp-on Transducer Problems (cont.)

**3.** INTERNAL DAMAGE

Ultrasonic transducers consist of a ceramic "crystal" bonded to the transducer case. The bond between the crystal and the case may be damaged by extreme shock and by temperature extremes. The crystal itself can also be damaged by the same conditions. The internal wiring can be corroded or shorted if contaminants enter the transducer housing.

**4.** PHYSICAL DAMAGE

Transducers may be physically damaged by dropping them onto a hard surface or striking them against another object. Usually the connector on the transducer is the part that is damaged, as it is the most fragile. Minor damage may be repaired by carefully bending the connector back into shape. If the connector cannot be repaired, replace the transducers. Note that transducers must be replaced in pairs, and that after replacement the flowmeter parameters should be checked (see Chapter 3, *Programming Site Data*).

**5.** CYCLE SKIP CONDITION

A cycle skip is usually caused by a distorted or altered signal due to poor couplant, bad wall, or unusual fluid disturbances. To resolve a cycle skip, recouple both transducers with proper couplant. Try standard CPL-1 couplant that is good to 212°F or CPL-2 for up to 500°F. In addition, make sure the pipe wall is free of paint and rust.

Contact Panametrics if you cannot solve a transducer-related problem.

## Clamp-on Transducer Problems (cont.)

If the coupling or pipe wall are not the problem, try relocating the transducers using the following method. However, before beginning, make sure the transducers are not located on or near pipe welds or seams:

- Move the upstream transducer about a 1/2 inch (12.7 mm) closer to the downstream transducer. If this resolves the problem you must modify the "S" dimension programmed into the TransPort by using the following steps:

1. Press the [PROG] key.

2. Choose CH1, CH2, SUM, DIF, or AVE.

3. Press [F3] to select "PIPE."

4. Press the up arrow key [↑] until the transducer spacing prompt appears.

5. Use the numeric keys to enter the transducer spacing. Subtract 0.5 in. (12.7 mm) from the original "S" and enter the new "S" dimension.

6. Press the [ENT] key.

## Clamp-on Transducer Problems (cont.)

• Move the downstream transducer about 1/2 inch (12.7 mm) closer to the upstream transducer. If this resolves the problem you must modify the "S" dimension programmed into the TransPort by using the following steps:

1. Press the [PROG] key.

2. Choose CH1, CH2, SUM, DIF, or AVE.

3. Press [F2] to select "PIPE."

4. Press the up arrow key [↑] until the transducer spacing prompt appears.

5. Use the numeric keys to enter the transducer spacing. Subtract 0.5 in. (12.7 mm) from the original "S" and enter the new "S" dimension.

6. Press the [ENT] key.

If these methods do not resolve the problem, contact Panametrics.

# Chapter 11

# Specifications

This section contains specifications for the following:

- Overall

- Electrical

- Transducer

- Fluid Types

- Pipe Size and Materials

- Available Options

# Overall

Flow Accuracy (% of reading):

Clamp-on Transducers: **Pipe Diameter > 150 mm (6")**

Velocity >0.3 m/s (>1 ft/s): 2 % typical (1% with calibration)

Velocity ≤0.3 m/s (≤1 ft/s): ±0.01 m/s (±0.03 ft/s) typical

**Pipe Diameter ≤ 150 mm (6")**

Velocity >0.3 m/s (>1 ft/s): 2-5% typical

Velocity <0.3 m/s (<1 ft/s): ±0.05 m/s typical (±0.15 ft/s)

Range:                      -12.2 to 12.2 m/s (-40 to 40 ft/s)

Rangeability:               400:1

Repeatability:              ±0.2% to 0.5% clamp-on transducers.

Energy Accuracy
(% of reading):             The accuracy of the energy measurement is a combination of the accuracy of the flow and temperature measurement. Accuracy of 1% is typical for calibrated systems.

European Compliance         This unit complies with EMC Directive 89/336/EEC and European Standard Low Voltage Directive EN 61010, Installation Category II, Pollution Degree II.

**Note:** *Above specifications require a straight run of 10 pipe diameters upstream and 5 pipe diameters downstream.*

# Electrical

**Meter**

Operating Power:     6 W, maximum.

Fuses:     One 250 mA, 32 V.
Two 1 A, 125 V, Slo-Blo.

**Internal Batteries**

Size:     4 C NiCad high-energy rechargeable batteries.

Battery Life:     4-6 hours of continuous operation is typical.  The battery life will be reduced if you use the printer output, the 4-20 mA ouput and/or loop powered temperature inputs, or the backlight.

Recharge Time:     16-20 hours using the external power supply/charger.

**Power Supply/Charger**

Input:     100/120 VAC or 200/260 VAC, 50/60 Hz ±10%, 5 W maximum

Output:     12 VDC unregulated

**Note:** *The 2PT868 may also be powered/charged by any regulated DC source that provides spike-free voltage of 10 to 28 VDC.*

**Size/Weight**

Size:     12.7 mm x 22.9 mm x 5.8 cm
(5 x 9 x 2.3 inches)

Weight:     1.0 kg (2.2 lbs)

# Electrical (cont.)

### Environmental

Operating Temperature: -10 to 50°C (14 to 122°F)

Storage
Temperature:                -10 to 50°C (14 to 122°F)

**Note:** *To ensure maximum battery life, the storage temperature should not exceed 35°C (95°F) for long periods.*

### Operating Modes

Flow
Measurement:                Transit-time clamp-on or wetted transducers

Energy:                     Two loop-powered temperature transmitter inputs to calculate energy flow

### Input/Output

Keypad:                     30-key tactile feedback membrane keypad

Display:                     64 x 128 pixel LCD graphic display with backlight

Printer/                    One RS232 port for printer, terminal, or
Terminal:                   PC

Analog Output:              Two 4-20 mA or 0-20 mA current output (550 Ω maximum load)

Analog Input:               Two 4-20 mA analog inputs with switchable 16 V supply for loop-powered temperature transmitters.

Acoustic:                   Two pairs of LEMO coaxial transducer connectors. Cable length 8 m (25 ft) standard. Up to 305 m (1,000 ft) optional.

# Electrical (cont.)

**Operational Specifications**

Site Parameter
Programming:                Menu-driven operator interface using a
                            keypad and "soft"functions keys. On-
                            line help functions including pipe tables.
                            Storage for saving parameters for up to
                            10 sites.

Data Logging:               Memory capacity to log over 43,000
                            flow data points. Keypad programmable
                            for log units, update times and start and
                            stop times.

Display Functions:          Graphic displays shows flow in numeric
                            or graphical format. Also displays
                            logged data.

Printer Output:             Supports several thermal or impact
                            printers. Output data in numeric or
                            graphical ("strip chart") format.

# Transducer

**Clamp-On**

Standard:                         Panametrics' clamp-on and wetted
                                  transducers

Temperature Range:     -40 to 100°C (-40 to 212°F) standard

Optional Temperature
Range:                        -200 to 260°C (-328 to 500°F)

Frequency:                   1 MHz standard

Optional Frequencies:   500 kHz, 2 MHz, 4 MHz

**Note:** *Transducers for special applications are available.*
*Flowcells are also available. Consult Panametrics for*
*details.*

Optional
Materials:                   Stainless steel, high-temperature
                                  plastics, Hastelloy, Monel, Titanium, etc.

Mounting:                    Chain, strap, or magnetic slide track
                                  mounting fixtures

**Temperature Transducers**

Loop-powered 3-wire platinum RTDs; clamp-on and wetted
(thermowell) types are available.

Accuracy:                    0.1°C (0.2°F), wetted RTDs (matched
                                  pairs)

Range:                        -20 to 260°C (-4 to 500°F)

# Pipe Size and Material

Clamp-On Transducers: **Materials**:

All metals, most plastics; consult Panametrics for concrete, wood, and composite materials for highly corroded, or lined pipes.

**Pipe Sizes:**
12.7 mm to 5 m outside (OD)
(0.5 to 200")

**Pipe Wall Thickness:**
Up to 76.2 mm (3")

Wetted Transducers: **Materials:**

All metals, most plastics; consult Panametrics for concrete, glass, and cement.

**Pipe Sizes:**
1 mm to 5 m inside diameter (ID)
(0.04 to 200").

# Available Options

### Thickness Gauge

Standard Transducer: Panametrics dual element transducer

Pipe Wall Thickness
Range: 1.3 to 76.2 mm (0.05 to 3.0 inches)

Pipe Materials: Most standard metal and plastic pipe
materials

Accuracy: 1% typical or ±0.05 mm (±0.002 inches)

Display Resolution: 0.01 mm (0.001 inches)

Thermal Exposure: Continuous operation to 37°C (100°F).
Intermittent operation to 260°C (500°F)
for 10 seconds followed by air cooling
for 2 minutes.

### Energy Equipment

Dual RTD transmitter; two 4 to 20 mA
transmitters with input for 3-wire RTD
(100 Ω pt) and terminals for 4 to 20 mA
output; 6 ft. cable.

### Printer

Thermal printer with reachargeable
battery, 6 ft. cable and 120 VAC or 240
VAC charger.

### PC Interface Software

TransPort Data Manager (TDM)
software links 2PT868 wth computer or
PC. Includes 3.5 in. and 5.25 in.
diskettes, interconnection cable (please
specify type), and manual.*

* In normal single-phase situations only.

# Appendix A
# Entering Special Transducer Pipe Parameters

If you are using special transducers, the TransPort should be completely programmed when you receive your unit. However, in the unlikely event that data is lost, use this section to properly program pipe parameters.

The series of prompts that appear in this menu depend on the type of special transducers you are using: wetted or clamp-on. (Refer to the *Liquid Transducer Installation Guide* (916-055) for additional information about transducers and configurations.)

The first prompt asks you to enter the transducer number. Since special transducers do not have a number engraved on the head (like standard transducers), you must specify it as a special and then assign it a number between 91 and 99. Refer to Appendix F, Menu Maps, Figures F-1C & F-1D for flow diagrams of the PIPE options.

Before beginning this section, you should have entered the proper system parameters in the SYSTeM option as described in Chapter 3, *Programming Site Data.*

# Entering Pipe Parameters

To enter the Pipe Menu, do the following:

**1.** Press the [PROG] key to enter the Program Menu.

**2.** Press the appropriate feature key to select the channel you want.

**3.** Press [F3] to select "PIPE."

A screen similar to Figure A-1 below appears.

```
Chan 1     PIPE PROG
Channel PROGRAM
Pipe parameters

TRANSDUCER NUMBER
91
 SPEC
```
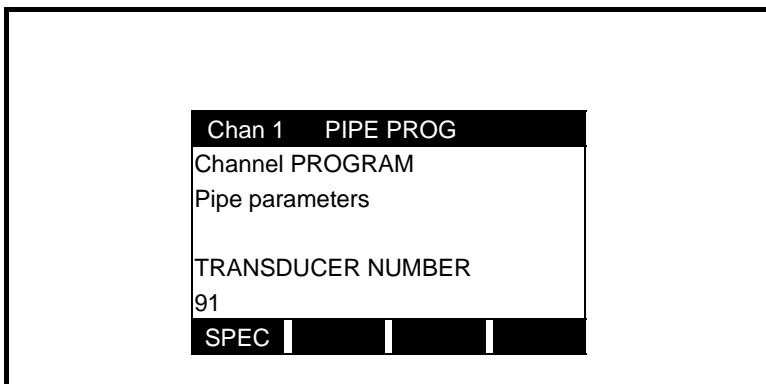
**Figure A-1: Screen After Pressing PIPE Key**

### Step 1: Entering the Transducer Number
The first prompt asks you to enter the transducer number. Because you are using a special transducer, do the following:

**1.** Press [F1] to tell the TransPort you are using a special transducer.

**2.** The next prompt asks you to enter a number. The TransPort allows you to store more than one set of special transducers; therefore, assign a number from 91-99.

**3.** Press [ENT].

# Entering Pipe Parameters (cont.)

## Step 2: Selecting the Wedge Type

The next prompt asks you to select the wedge type. The TransPort gives you three choices: Rayleigh wave, Shear wave, or wetted transducers. Use the appropriate function key to make your choice.

Depending on the type of transducers you are using, do one of the following:

- If you are using Rayleigh or Shear wave clamp-on transducers, follow the instructions for clamp-on transducers on pages A-4 to A-10.

- If you are using wetted transducers, follow the instructions for wetted transducers on pages A-10 to A-14.

## Entering Parameters for Clamp-On Transducers

If you are using Rayleigh or Shear wave clamp-on transducers, you will get the following prompts:

- Frequency

- Tw (time delay)

- Wedge Angle

- Wedge Sound Speed

- Pipe Material

- Pipe O.D. (pipe outside diameter)

- Pipe Wall Thickness

- Lining (material and thickness)

- Fluid Type

- Reynolds Correction Factor

- Calibration Factor

- Number of Traverses

- Transducer Spacing

Some of the above parameters are supplied by Panametrics on a sheet of paper inside the transducer case. Refer to this sheet when instructed.

## Entering Parameters for Clamp-On Transducers (cont.)

### Step 3C: Entering the Frequency

The next prompt asks you to enter the transducer frequency. The TransPort needs to know the frequency in order to transmit a voltage at a rate the transducer can respond to.

Use the appropriate function key to select one of the following choices, then press [ENT].

- 500 kHz

- 1 MHz

- MHz

- 4 MHz

### Step 4C: Entering the Time Delay

The next prompt asks you to enter the time delay (Tw). The time delay is the time the transducer signal spends travelling through the transducer and cable. This time must be taken into consideration, since the TransPort uses the signal travel time to calculate the flow rate.

Use the numeric keys to enter the Panametrics-supplied time delay (in microseconds), then press [ENT].

### Step 5C: Entering the Transducer Wedge Angle

The next prompt asks for the wedge angle for clamp-on transducers. The angle of the ultrasonic transmission must be taken into account when calculating the flow rate.

Use the numeric keys to enter the Panametrics supplied transducer wedge angle (in degrees) and press [ENT].

### Step 6C: Entering the Transducer Wedge Sound Speed

In addition to the angle, clamp-on transducers require that you enter the sound speed of the wedge. Use the numeric keys to enter the Panametrics supplied wedge sound speed (in ft/sec or m/sec) and press [ENT].

## Entering Parameters for Clamp-On Transducers (cont.)

### Step 7C: Entering the Pipe Material

The next prompt asks you to enter the pipe material. Since clamp-on transducers send their ultrasonic signals through the pipe wall, the sound speed of the pipe material must be factored in to obtain an accurate flow measurement.

Clamp-on transducers are applicable on a variety of pipe materials, only a few of which are among the options for this prompt. If your pipe material is not among the options, select "OTHER" and enter the sound speed of your pipe material from the tables in Appendix B.

Use the following steps to enter the pipe material:

1. Use the arrow keys to view all the pipe material categories. See Table A-1 on page A-6 for the available categories.

2. Press the appropriate function key to choose the desired category.

3. Depending on the pipe material choice, the next prompt may asks you to choose a specific material. Use the arrow keys to view all the pipe materials. See Table A-1 on page A-6 for available options.

**Note:** *If you choose brass, copper, or aluminum, skip to the next section, "Entering the Outside Diameter of the Pipe."*

4. Press the appropriate function key to choose the desired material.

Entering Parameters for Clamp-On Transducers
(cont.)

**Table A-1: Pipe Materials**

| Pipe Material Category | Specific Material |
|---|---|
| Steel | Carbon Steel or Stainless Steel |
| Iron | Ductile Iron or Cast Iron |
| Cu - Copper | None |
| Al - Aluminum | None |
| Brass | None |
| CuNi - Copper/Nickel | 70% Cu 30% Ni or 90% Cu 10% Ni |
| Glass | Pyrex, Flint, or Crown |
| Plastic | Nylon, Polyester, Polypropylene, PVC (CPVC), or Acrylic |
| Other* | User-defined |

 *If you select "OTHER," the TransPort prompts you to enter the sound speed of the pipe material.

### Step 8C: Entering the Outside Diameter of the Pipe
The next prompt for clamp-on transducers is pipe outside diameter (OD). If you do not know the outside diameter of your pipe, Appendix B contains some standard pipe sizes with their corresponding outside diameters. Otherwise, measure it.

To enter the outside diameter:

**1.** Press the appropriate function key to select the units.

**2.** Use the numeric keys to enter the outside diameter.

**3.** As an alternative, use "in/PI" or "ft/PI" to enter circumference. The TransPort will calculate the outside diameter after you enter a numeric value. Press "inch" or "feet" to see that calculated value of OD.

**4.** Press ENT.

Entering Parameters for Clamp-On Transducers
(cont.)

### Step 9C: Entering the Pipe Wall Thickness

The next prompt asks you to enter the thickness of the pipe wall.
If you are not sure of the pipe wall thickness, Appendix B
contains some standard pipe sizes with their corresponding wall
thicknesses. Also, the pipe wall thickness can be determined by
using the optional internal ultrasonic thickness gauge as
described in Chapter 9, *Using the Ultrasonic Thickness Gauge.*
To enter the pipe wall thickness:

**1.** Use the numeric keys to enter the pipe wall thickness.

**2.** Press [ENT].

### Step 10C: Entering Pipe Lining

The next prompt asks you to enter the pipe lining material.
Clamp-on transducers can be used on pipes with a variety of pipe
linings; however, only a few are among the options. If your lining
is not among the options, select "OTHER" and enter the sound
speed of your lining material from the tables in Appendix B.

If your pipe does not have a lining, press [F1] to respond no and
the TransPort proceeds to the next prompt.

If your pipe does have a lining, use the following steps to enter
lining information:

**1.** Press [F2].

**2.** The next prompt asks you to choose the lining material. Use
the appropriate function key to respond.

**Note:** *If you choose "OTHER," the TransPort then asks you to
enter the lining sound speed. If you do not know the lining
sound speed, Appendix B lists some standard materials
and their corresponding sound speeds.*

## Entering Parameters for Clamp-On Transducers (cont.)

**3.** The next prompt asks you to enter the pipe lining thickness. Use the numeric keys to enter the lining thickness.

**4.** Press [ENT].

### Step 11C: Entering the Fluid Type
This prompt asks you to enter the fluid type. You may choose one of the following:

- Water

- Water/glycol mixture (for energy option only)

- Oil (lube or crude)

- Methanol

- Ethanol

- LN2

- Freon

- Other

Use the appropriate feature key to make a choice. Depending on the fluid type you choose, the TransPort may ask you for additional information.

**Note:** *If you select "OTHER," the TransPort prompts you to enter the sound speed of the fluid.*

### Step 12C: Entering the Reynolds Correction Factor
The next prompt asks if you want to enable or disable the Reynolds Correction Factor, which is a number based on the viscosity and flow rate of the fluid. Generally, it should only be enabled when using transducers mounted in a diametrical path (such as clamp-on or tilted diameter). If you enable the Reynolds Correction Factor, you will also need to enter the Kinematic Viscosity of the fluid (units are $ft^2$/sec or $m^2$/sec depending on the units selected). Refer to Appendix B for the Kinematic Viscosity of your fluid.

## Entering Parameters for Clamp-On Transducers (cont.)

To disable the Reynolds Factor, press [F1]. To enable it, do the following:

1. Press [F2].

2. The next prompt asks you to enter the Kinematic Viscosity. Use the numeric keys to enter the Kinematic Viscosity (refer to Appendix B).

3. Press [ENT].

### Step 13C: Entering the Calibration Factor

The next prompt asks you to enter a value for the Calibration Factor, which is used as a reference for the flowmeter electronics to ensure accurate readings. Generally, if you enable the Reynolds Correction Factor, the correction factor should be set to 1.00; otherwise, the typical factor is between .50 and 2.00.

Use the numeric keys to enter a value, then press [ENT].

### Step 14C: Entering the Number of Traverses

This prompt asks you to enter the number of times the ultrasonic signal will traverse the pipe (refer to the *Liquid Transducer Installation Guide* (916-005)). The number of traverses is determined by such factors as pipe sizes, pipe wall absorption properties, and accuracy desired. We generally recommend trying two-traverse first.

Use the arrow keys to view all the options, then press the appropriate feature key to respond.

### Step 15C: Display of Transducer Spacing

The next prompt shows the actual spacing of the transducers, which is calculated from the information entered. Use the *Liquid Transducer Installation Guide* (916-055) as a guide to installing the transducers on the pipe, with the spacing dimension (S) given here.

Set the transducers to the spacing shown at this prompt.

## Entering Parameters for Clamp-On Transducers (cont.)

**Note:** *If necessary, the spacing calculated by the unit can be overwritten (using the numeric keys) to match the actual physical spacing of the transducers.*

You have completed entering data into the PIPE option. You may at this time do one of the following:

- Use the up and down arrow keys to verify or change data.

- Continue to enter data in other menus as described in Chapter 3, *Programming Site Data.*

- Press [EXIT] to exit the Program Menu and begin taking measurements.

*If you do decide to exit, you must have already programmed the system parameters in order to make flow measurements.*

## Entering Parameters for Wetted Transducers

If you are using wetted transducers, you will get the following prompts:

- Frequency
- Tw (time delay)
- Pipe O.D. (pipe outside diameter)
- Pipe Wall
- Path Length (P)
- Axial Dimension (L)
- Fluid Type
- Reynolds Correction Factor
- Calibration Factor

**Step 3W: Entering the Frequency**

The next prompt asks you to enter the transducer frequency. The TransPort needs to know the frequency to transmit a voltage at a rate to which the transducer can respond.

## Entering Parameters for Wetted Transducers (cont.)

Use the appropriate function key to select one of the following choices, then press [ENT].

- 500 kHz

- 1 MHz

- 2 MHz

- 4 MHz

### Step 4W: Entering the Time Delay

This prompt asks you to enter the time delay (Tw). The time delay is the time the transducer signal spends travelling through the transducer and cable. This time must be taken into consideration, since the TransPort uses the signal travel time to calculate the flow rate.

Use the numeric keys to enter the Panametrics-supplied time delay (in microseconds), then press [ENT].

### Step 5W: Entering the Outside Diameter of the Pipe

The first prompt for wetted transducers is pipe outside diameter (OD). If you do not know the outside diameter of your pipe, Appendix B contains some standard pipe sizes with their corresponding outside diameters or measure it.

To enter the outside diameter:

1. Press the appropriate function key to select the units.

2. Use the numeric keys to enter the outside diameter.

3. As an alternative, use "in/PI" or "ft/PI" to enter circumference. The TransPort will calculate the outside diameter after you enter a numeric value. Press "inch" or "feet" to see that calculated value of OD.

4. Press ENT.

## Entering Parameters for Wetted Transducers (cont.)

### Step 6W: Entering the Pipe Wall Thickness

The next prompt asks you to enter the thickness of the pipe wall. If you are not sure of the pipe wall thickness, Appendix B contains some standard pipe sizes with their corresponding wall thicknesses. Also, the pipe wall thickness can be determined by using the optional internal ultrasonic thickness gauge as described in Chapter 9, *Using the Ultrasonic Thickness Gauge.*

Use the numeric keys to enter the pipe wall thickness, then press [ENT].

### Step 7W: Entering the Path Length (P)

The next prompt asks you to enter the path length (P) of the ultrasonic signal. Panametrics has calculated the path length based on the transducer configuration for your particular application. Find the path length on the flowcell or on other supplied documentation.

**1.** Press the appropriate function key to select the desired units.

**2.** Use the numeric keys to enter the path length.

**3.** Press [ENT].

**Note:** *If the path length is not supplied, refer to Appendix C to measure the path length.*

### Step 8W: Enter the Axial Length (L)

The next prompt asks you to enter the axial length (L) of the ultrasonic signal. Panametrics has calculated the axial dimension based on the transducer configuration for your particular application. Find the axial dimension on the flowcell or from other supplied documentation.

**1.** Press the appropriate function key to select the desired units.

**2.** Use the numeric keys to enter the axial length.

**3.** Press [ENT].

## Entering Parameters for Wetted Transducers (cont.)

**Note:** *If the axial length is not supplied, refer to Appendix C to measure the axial length.*

### Step 9W: Entering the Fluid Type

This prompt asks you to enter the fluid type. You may choose one of the following:

- Water

- Water/glycol mixture (for energy option only)

- Oil (lube or crude)

- Methanol

- Ethanol

- LN2

- Freon

- Other

Use the appropriate feature key to make a choice. Depending on the fluid type you choose, the TransPort may ask you for additional information.

**Note:** *If you select "OTHER," the TransPort prompts you to enter the sound speed of the fluid.*

### Step 10W: Entering the Reynolds Correction Factor

The next prompt asks if you want to enable or disable the Reynolds Correction Factor, which is a number based on the viscosity of the fluid. Generally, it should only be enabled when using transducers mounted in a diametrical path (such as clamp-on or tilted diameter). If you enable the Reynolds Correction Factor, you will also need to enter the Kinematic Viscosity of the fluid (units are in $ft^2$/sec or $m^2$/sec depending on the units selected). Refer to Appendix B for the Kinematic Viscosity of your fluid.

## Entering Parameters for Wetted Transducers (cont.)

To disable the Reynolds Factor, press [F1]. To enable it, do the following:

1. Press [F2].

2. The next prompt asks you to enter the Kinematic Viscosity. Use the numeric keys to enter the Kinematic Viscosity (refer to Appendix B).

3. Press [ENT].

### Step 11W: Entering the Calibration Factor

The next prompt asks you to enter a value for the Calibration Factor, which is used as a reference for the flowmeter electronics to ensure accurate readings. Generally, if you enable the Reynolds Correction Factor, the correction factor should be set to 1.00. Otherwise the typical factor is between .50 and 2.00.

Use the numeric keys to enter a value and press [ENT].

You have completed entering data into the PIPE option. You may at this time do one of the following:

- Use the up and down arrow keys to verify or change data.

- Continue to enter data in other menus as described in Chapter 3, *Programming Site Data.*

- Press [EXIT] to exit the Program Menu and begin taking measurements.

*If you do decide to exit, you must have already programmed the system parameters in order to make flow measurements.*

# Appendix B

# Sound Speeds and Pipe Size Data

The values in Table 1 below are reproduced with permission: shear wave values from the *American Institute of Physics Handbook*, Smithsonian Tables; longitudinal values from the *Nondestructive Testing Handbook*, 2nd edition, Volume 7, *Ultrasonic Testing*. ©1991, The American Society of Nondestructive Testing.

## Table 1:  Sound Speeds in Solids

| Material | Sound Speed* Shear Wave (25°C) | | Sound Speed* Long. Wave (25°C) | |
|---|---|---|---|---|
| | m/s | ft/s | mm/µs | in./µs |
| Steel, 1% Carbon, hardened | 3,150 | 10,335 | 5.88 | 0.2315 |
| Carbon Steel | 3,230 | 10,598 | 5.89 | 0.2319 |
| Mild Steel | 3,235 | 10,614 | 5.89 | 0.2319 |
| Steel, 1% Carbon | 3,220 | 10,565 | | |
| 302 Stainless Steel | 3,120 | 10,236 | 5.66 | 0.2223 |
| 303 Stainless Steel | 3,120 | 10,236 | 5.66 | 0.2223 |
| 304 Stainless Steel | 3,075 | 10,089 | | |
| 316 Stainless Steel | 3,175 | 10,089 | 5.31 | 0.2090 |
| 347 Stainless Steel | 3,100 | 10,171 | 5.74 | 0.2260 |
| 410 Stainless Steel | 2,990 | 9,810 | 5.39 | 0.2122 |
| 430 Stainless Steel | 3,360 | 11,024 | | |
| Aluminum | 3,100 | 10,171 | 6.32 | 0.2488 |
| Aluminum (rolled) | 3,040 | 9,974 | | |
| Copper | 2,260 | 7,415 | 4.66 | 0.1835 |

*Please note these values are to be considered nominal. Solids may be inhomogenous and anisotropic. Actual values depend on exact composition, temperature, and to a lesser extent, on pressure or stress.*

## Table 1:  Sound Speeds in Solids (cont.)

| Material | Sound Speed* Shear Wave (25°C) | | Sound Speed* Long. Wave (25°C) | |
|---|---|---|---|---|
| | m/s | (ft/s) | mm/µs | in/µs |
| Copper (annealed) | 2,325 | 7,628 | | |
| Copper (rolled) | 2,270 | 7,448 | | |
| CuNi (70%Cu 30%Ni) | 2,540 | 8,334 | 5.03 | 0.1980 |
| CuNi (90%Cu 10%Ni) | 2,060 | 6,759 | 4.01 | 0.1579 |
| Brass (Naval) | 2,120 | 6,923 | 4.43 | 0.1744 |
| Gold (hard-drawn) | 1,200 | 3,937 | 3.24 | 0.1276 |
| Inconel | 3,020 | 9,909 | 5.82 | 0.2291 |
| Iron (electrolytic) | 3,240 | 10,630 | 5.90 | 0.2323 |
| Iron (Armco) | 3,240 | 10,630 | 5.90 | 0.2323 |
| Ductile Iron | 3,000 | 9,843 | | |
| Cast Iron | 2,500 | 8,203 | 4.55 | 0.1791 |
| Monel | 2,720 | 8,924 | 5.35 | 0.2106 |
| Nickel | 2,960 | 9,712 | 5.63 | 0.2217 |
| Tin, rolled | 1,670 | 5,479 | 3.32 | 0.1307 |
| Titanium | 3,125 | 10,253 | 6.10 | 0.2402 |
| Tungsten, annealed | 2,890 | 9,482 | 5.18 | 0.2039 |
| Tungsten, drawn | 2,640 | 8,661 | | |
| Tungsten, carbide | 3,980 | 13,058 | | |
| Zinc, rolled | 2,440 | 8,005 | 4.17 | 0.1642 |
| Glass, Pyrex | 3,280 | 10,761 | 5.61 | 0.2209 |
| Material | m/s | (ft/s) | mm/µs | in/µs |
| Glass, heavy silicate flint | 2,380 | 7,808 | | |

*Please note these values are to be considered nominal. Solids may be inhomogenous and anisotropic. Actual values depend on exact composition, temperature, and to a lesser extent, on pressure or stress.*

## Table 1:  Sound Speeds in Solids (cont.)

| | Sound Speed*<br>Shear Wave (25°C) | | Sound Speed*<br>Long. Wave (25°C) | |
|---|---|---|---|---|
| Glass,<br>light borate crown | 2,840 | 9,318 | 5.26 | 0.2071 |
| Nylon | 1,150 | 3,772 | 2.40 | 0.0945 |
| Nylon, 6-6 | 1,070 | 3,510 | | |
| Polyethylene (HD) | | | 2.31 | 0.0909 |
| Polyethylene (LD) | 540 | 1,772 | 1.94 | 0.0764 |
| PVC, CPVC | 1,060 | 3,477 | 2.40 | 0.0945 |
| Acrylic | 1,430 | 4,690 | 2.73 | 0.1075 |
| Asbestos Cement | | | 2.20 | 0.0866 |
| Tar Epoxy | | | 2.00 | 0.0787 |
| Mortar | | | 2.50 | 0.0984 |
| Rubber | | | 1.90 | 0.0748 |
| *Please note these values are to be considered nominal. Solids may be inhomogenous and anisotropic. Actual values depend on exact composition, temperature, and to a lesser extent, on pressure or stress.* | | | | |

## Table 2:  Sound Speeds in Fluids

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Acetic anhy-dride (22) | $(CH_3CO)_2O$ | 1.082 (20°C) | 1,180 | 3,871.4 | 2.5 | 0.769 | 8.274 |
| Acetic acid, anhydride (22) | $(CH_3CO)_2O$ | 1.082 (20°C) | 1,180 | 3,871.4 | 2.5 | 0.769 | 8.274 |
| Acetic acid, nitrile | $C_2H_3N$ | 0.783 | 1,290 | 4,232.3 | 4.1 | 0.441 | 4.745 |
| Acetic acid, ethyl ester (33) | $C_4H_8O_2$ | 0.901 | 1,085 | 3,559.7 | 4.4 | 0.467 | 5.025 |
| Acetic acid, methyl ester | $C_3H_6O_2$ | 0.934 | 1,211 | 3,973.1 | | 0.407 | 4.379 |
| Acetone | $C_3H_6O$ | 0.791 | 1,174 | 3,851.7 | 4.5 | 0.399 | 4.293 |
| Acetonitrile | $C_2H_3N$ | 0.783 | 1,290 | 4,232.3 | 4.1 | 0.441 | 4.745 |
| Acetonylace-tone | $C_6H_{10}O_2$ | 0.729 | 1,399 | 4,589.9 | 3.6 | | |
| Acetylen dichloride | $C_2H_2Cl_2$ | 1.26 | 1,015 | 3,330.1 | 3.8 | 0.400 | 4.304 |
| Acetylene tetrabromide (47) | $C_2H_2Br_4$ | 2.966 | 1,027 | 3,369.4 | | | |
| Acetylene tet-rachloride (47) | $C_2H_2Cl_4$ | 1.595 | 1,147 | 3,763.1 | | 1.156 (15°C) | 12.438 (59°F) |
| Alcohol | $C_2H_6O$ | 0.789 | 1,207 | 3,960 | 4.0 | 1.396 | 15.02 |
| Alkazene-13 | $C_{15}H_{24}$ | 0.86 | 1,317 | 4,320.9 | 3.9 | | |
| Alkazene-25 | $C_{10}H_{12}Cl_2$ | 1.20 | 1,307 | 4,288.1 | 3.4 | | |
| 2-Amino-ethanol | C2H7NO | 1.018 | 1,724 | 5,656.2 | 3.4 | | |
| 2-Aminotoli-dine (46) | $C_7H_9N$ | 0.999 (20°C) | 1,618 | 5,308.4 | | 4.394 (20°C) | 47.279 (68°F) |
| 4-Aminotoli-dine (46) | $C_7H_9N$ | 0.966 (45°C) | 1,480 | 4,855.6 | | 1.863 (50°C) | 20.045 (122°F) |

# Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x$10^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Ammonia (35) | $NH_3$ | 0.771 | 1,729 (-33°C) | 5,672.6 (-27°F) | 6.68 | 0.292 (-33°C) | 3.141 (-27°F) |
| Amorphous Polyolefin | | 0.98 | 962.6 (190°C) | 3158.2 (374°F) | | 26,600 | 286,000 |
| t-Amyl alcohol | $C_5H_{12}O$ | 0.81 | 1,204 | 3,950.1 | | 4.374 | 47.064 |
| Aminoben-zene (41) | $C_6H_5NO_2$ | 1.022 | 1,639 | 5,377.3 | 4.0 | 3.63 | 39.058 |
| Aniline (41) | $C_6H_5NO_2$ | 1.022 | 1,639 | 5,377.3 | 4.0 | 3.63 | 39.058 |
| Argon (45) | Ar | 1.400 (-188°C) | 853 (-188°C) | 2798.6 (-306°F) | | | |
| Azine | $C_6H_5N$ | 0.982 | 1,415 | 4,642.4 | 4.1 | 0.992 (20°C) | 10.673 (68°F) |
| Benzene (29, 40, 41) | $C_6H_6$ | 0.879 | 1,306 | 4,284.8 | 4.65 | 0.711 | 7.65 |
| Benzol (29, 40, 41) | $C_6H_6$ | 0.879 | 1,306 | 4,284.8 | 4.65 | 0.711 | 7.65 |
| Bromine (21) | $Br_2$ | 2.928 | 889 | 2,916.7 | 3.0 | 0.323 | 3.475 |
| Bromo-benzene (46) | $C_6H_5Br$ | 1.522 | 1,170 (20°C) | 3,838.6 (68°F) | | 0.693 | 7.456 |
| 1-Bromo-butane (46) | $C_4H_9Br$ | 1.276 (20°C) | 1,019 (20°C) | 3,343.2 (68°F) | | 0.49 (15°C) | 5.272 (59°F) |
| Bromo-ethane (46) | $C_2H_5Br$ | 1.460 (20°C) | 900 (20°C) | 2,952.8 (68°F) | | 0.275 | 2.959 |
| Bromoform (46, 47) | $CHBr_3$ | 2.89 (20°C) | 918 | 3,011.8 | 3.1 | 0.654 | 7.037 |
| n-Butane (2) | $C_4H_{10}$ | 0.601 (0°C) | 1,085 (-5°C) | 3,559.7 (23°F) | 5.8 | | |
| 2-Butanol | $C_4H_{10}O$ | 0.81 | 1,240 | 4,068.2 | 3.3 | 3.239 | 34.851 |
| sec-Butylalcohol | $C_4H_{10}O$ | 0.81 | 1,240 | 4,068.2 | 3.3 | 3.239 | 34.851 |

# Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | *All data given at 25°C (77°F) unless otherwise noted.* | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10⁻⁶ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m²/s | ft²/s |
| n-Butyl bromide (46) | $C_4H_9Br$ | 1.276 (20°C) | 1,019 (20°C) | 3,343.2 (68°F) | | 0.49 (15°C) | 5.272 (59°F) |
| n-Butyl chloride (22, 46) | $C_4H_9Cl$ | 0.887 | 1,140 | 3,740.2 | 4.57 | 0.529 (15°C) | 5.692 (59°F) |
| tert Butyl chloride | $C_4H_9Cl$ | 0.84 | 984 | 3,228.3 | 4.2 | 0.646 | 6.95 |
| Butyl oleate | $C_{22}H_{42}O_2$ | | 1,404 | 4,606.3 | 3.0 | | |
| 2, 3 Butylene glycol | $C_4H_{10}O_2$ | 1.019 | 1,484 | 4,868.8 | 1.51 | | |
| Cadmium (7) | Cd | | 2,237.7 (400°C) | 7,341.5 (752°F) | | 1.355cp (440°C) | 14.579 (824°F) |
| Carbinol (40, 41) | $CH_4O$ | 0.791 (20°C) | 1,076 | 3,530.2 | 2.92 | 0.695 | 7.478 |
| Carbitol | $C_6H_{14}O_3$ | 0.988 | 1,458 | 4,783.5 | | | |
| Carbon dioxide (26) | $CO_2$ | 1.101 (-37°C) | 839 (-37°C) | 2,752.6 (-35°F) | 7.71 | 0.137 (-37°C) | 1.474 (-35°F) |
| Carbon disulphide | $CS_2$ | 1.261 (22°C) | 1,149 | 3,769.7 | | 0.278 | 2.991 |
| Carbon tetrachloride (33, 35, 47) | $CCl_4$ | 1.595 (20°C) | 926 | 3038.1 | 2.48 | 0.607 | 6.531 |
| Carbon tetrafluoride (14) (Freon 14) | $CF_4$ | 1.75 (-150°C) | 875.2 (-150°C) | 2,871.5 (-238°F) | 6.61 | | |
| Cetane (23) | $C_{16}H_{34}$ | 0.773 (20°C) | 1,338 | 4,389.8 | 3.71 | 4.32 | 46.483 |
| Chloro-benezene | $C_6H_5Cl$ | 1.106 | 1,273 | 4,176.5 | 3.6 | 0.722 | 7.768 |
| 1-Chloro-butane (22, 46) | $C_4H_9Cl$ | 0.887 | 1,140 | 3,740.2 | 4.57 | 0.529 (15°C) | 5.692 (59°F) |
| Chloro-diFluoro-romethane (3) (Freon 22) | $CHClF_2$ | 1.491 (-69°C) | 893.9 (-50°C) | 2,932.7 (-58°F) | 4.79 | | |

# Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Chloroform (47) | CHCl$_3$ | 1.489 | 979 | 3,211.9 | 3.4 | 0.55 | 5.918 |
| 1-Chloro-pro-pane (47) | C$_3$H$_7$Cl | 0.892 | 1,058 | 3,471.1 | | 0.378 | 4.067 |
| Chlorotrifluo-romethane (5) | CClF$_3$ | | 724 (-82°C) | 2,375.3 (-116°F) | 5.26 | | |
| Cinnamalde-hyde | C$_9$H$_8$O | 1.112 | 1,554 | 5,098.4 | 3.2 | | |
| Cinnamic aldehyde | C$_9$H$_8$O | 1.112 | 1,554 | 5,098.4 | 3.2 | | |
| Colamine | C$_2$H$_7$NO | 1.018 | 1,724 | 5,656.2 | 3.4 | | |
| o-Cresol (46) | C$_7$H$_8$O | 1.047 (20°C) | 1,541 (20°C) | 5,055.8 (68°F) | | 4.29 (40°C) | 46.16 (104°F) |
| m-Cresol (46) | C$_7$H$_8$O | 1.034 (20°C) | 1,500 (20°C) | 4,921.3 (68°F) | | 5.979 (40°C) | 64.334 (104°F) |
| Cya-nomethane | C$_2$H$_3$N | 0.783 | 1,290 | 4,232.3 | 4.1 | 0.441 | 4.745 |
| Cyclohex-ane (15) | C$_6$H$_{12}$ | 0.779 (20°C) | 1,248 | 4,094.5 | 5.41 | 1.31 (17°C) | 14.095 (63°F) |
| Cyclohexanol | C$_6$H$_{12}$O | 0.962 | 1,454 | 4,770.3 | 3.6 | 0.071 (17°C) | 0.764 (63°F) |
| Cyclohex-anone | C$_6$H$_{10}$O | 0.948 | 1,423 | 4,668.6 | 4.0 | | |
| Decane (46) | C$_{10}$H$_{22}$ | 0.730 | 1,252 | 4,107.6 | | 1.26 (20°C) | 13.55 (68°F) |
| 1-Decene (27) | C$_{10}$H$_{20}$ | 0.746 | 1,235 | 4,051.8 | 4.0 | | |
| n-Decylene (27) | C$_{10}$H$_{20}$ | 0.746 | 1,235 | 4,051.8 | 4.0 | | |
| Diacetyl | C$_4$H$_6$O$_2$ | 0.99 | 1,236 | 4,055.1 | 4.6 | | |
| Diamylamine | C$_{10}$H$_{23}$N | | 1,256 | 4,120.7 | 3.9 | | |

## Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10⁻⁶ | |
|---|---|---|---|---|---|---|---|
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m²/s | ft²/s |
| 1,2 Dibromo-ethane (47) | $C_2H_4Br_2$ | 2.18 | 995 | 3,264.4 | | 0.79 (20°C) | 8.5 (68°F) |
| trans-1,2-Dibromoet-hene (47) | $C_2H_2Br_2$ | 2.231 | 935 | 3,067.6 | | | |
| Dibutyl phthalate | $C_8H_{22}O_4$ | | 1,408 | 4,619.4 | | | |
| Dichloro-t-butyl alcohol | $C_4H_8Cl_2O$ | | 1,304 | 4,278.2 | 3.8 | | |
| 2,3 Dichlo-rodioxane | $C_2H_6Cl_2O_2$ | | 1,391 | 4,563.6 | 3.7 | | |
| Dichlorodifluo-romethane (3) (Freon 12) | $CCl_2F_2$ | 1.516 (40°C) | 774.1 | 2,539.7 | 4.24 | | |
| 1,2 Dichloro ethane (47) | $C_2H_4Cl_2$ | 1.253 | 1,193 | 3,914 | | 0.61 | 6.563 |
| cis1,2-Dichloro-ethene (3, 47) | $C_2H_2Cl_2$ | 1.284 | 1,061 | 3,481 | | | |
| trans1,2-Dichloro-ethene (3, 47) | $C_2H_2Cl_2$ | 1.257 | 1,010 | 3,313.6 | | | |
| Dichloro-fluo-romethane (3) (Freon 21) | $CHCl_2F$ | 1.426 (0°C) | 891 (0°C) | 2,923.2 (32°F) | 3.97 | | |
| 1-2-Dichloro-hexafluoro-cyclobutane (47) | $C_4Cl_2F_6$ | 1.654 | 669 | 2,194.9 | | | |
| 1-3-Dichloro-isobutane | $C_4H_8Cl_2$ | 1.14 | 1,220 | 4,002.6 | 3.4 | | |
| Dichloro methane (3) | $CH_2Cl_2$ | 1.327 | 1,070 | 3,510.5 | 3.94 | 0.31 | 3.335 |
| 1,1-Dichloro-1,2,2,2 tetra fluoroethane | $CClF_2\text{-}CClF_2$ | 1.455 | 665.3 (-10°C) | 2,182.7 (14°F) | 3.73 | | |

All data given at 25°C (77°F) unless otherwise noted.

## Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
|---|---|---|---|---|---|---|---|
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Diethyl ether | $C_4H_{10}O$ | 0.713 | 985 | 3,231.6 | 4.87 | 0.311 | 3.346 |
| Diethylene glycol | $C_4H_{10}O_3$ | 1.116 | 1,586 | 5,203.4 | 2.4 | | |
| Diethylene glycol, monoethyl ether | $C_6H_{14}O_3$ | 0.988 | 1,458 | 4,783.5 | | | |
| Diethylenim-ide oxide | $C_4H_9NO$ | 1.00 | 1,442 | 4,731 | 3.8 | | |
| 1,2-bis(DiFlu-oramino) butane (43) | $C_4H_8(NF_2)_2$ | 1.216 | 1,000 | 3,280.8 | | | |
| 1,2-bis(DiFlu-oramino)-2-methylpropane (43) | $C_4H_9(NF_2)_2$ | 1.213 | 900 | 2,952.8 | | | |
| 1,2-bis(DiFlu-oramino) propane (43) | $C_3H_6(NF_2)_2$ | 1.265 | 960 | 3,149.6 | | | |
| 2,2-bis(DiFlu-oramino propane (43) | $C_3H_6(NF_2)_2$ | 1.254 | 890 | 2920 | | | |
| 2,2-Dihydrox-ydiethyl ether | $C_4H_{10}O_3$ | 1.116 | 1,586 | 5,203.4 | 2.4 | | |
| Dihydroxy-ethane | $C_2H_6O_2$ | 1.113 | 1,658 | 5,439.6 | 2.1 | | |
| 1,3-Dimethyl-benzene (46) | $C_8H_{10}$ | 0.868 (15°C) | 1,343 (20°C) | 4,406.2 (68°F) | | 0.749 (15°C) | 8.059 (59°F) |
| 1,2-Dimethyl-benzene (29, 46) | $C_8H_{10}$ | 0.897 (20°C) | 1,331.5 | 4,368.4 | 4.1 | 0.903 (20°C) | 9.716 (68°F) |
| 1,4-Dimethyl-benzene (46) | $C_8H_{10}$ | | 1,334 (20°C) | 4,376.6 (68°F) | | 0.662 | 7.123 |
| 2,2-Dimethyl-butane (29, 33) | $C_6H_{14}$ | 0.649 (20°C) | 1,079 | 3,540 | | | |
| Dimethyl ketone | $C_3H_6O$ | 0.791 | 1,174 | 3,851.7 | 4.5 | 0.399 | 4.293 |

*All data given at 25°C (77°F) unless otherwise noted.*

*Sound Speeds and Pipe Size Data*                    *B-9*

## Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Dimethyl pentane (47) | $C_7H_{16}$ | 0.674 | 1,063 | 3,487.5 | | | |
| Dimethyl phthalate | $C_8H_{10}O_4$ | 1.2 | 1,463 | 4,799.9 | | | |
| Diiodo-methane | $CH_2I_2$ | 3.235 | 980 | 3,215.2 | | | |
| Dioxane | $C_4H_8O_2$ | 1.033 | 1,376 | 4,514.4 | | | |
| Dodecane (23) | $C_{12}H_{26}$ | 0.749 | 1,279 | 4,196.2 | 3.85 | 1.80 | 19.368 |
| 1,2-Ethanediol | $C_2H_6O_2$ | 1.113 | 1,658 | 5,439.6 | 2.1 | | |
| Ethanenitrile | $C_2H_3N$ | 0.783 | 1,290 | 4,232.3 | | 0.441 | 4.745 |
| Ethanoic anhy-dride (22) | $(CH_3CO)_2O$ | 1.082 | 1,180 | 3,871.4 | | 0.769 | 8.274 |
| Ethanol | $C_2H_6O$ | 0.789 | 1,207 | 3,960 | 4.0 | 1.39 | 14.956 |
| Ethanol amide | $C_2H_7NO$ | 1.018 | 1,724 | 5,656.2 | 3.4 | | |
| Ethoxy-ethane | $C_4H_{10}O$ | 0.713 | 985 | 3,231.6 | 4.87 | 0.311 | 3.346 |
| Ethyl acetate (33) | $C_4H_8O_2$ | 0.901 | 1,085 | 3,559.7 | 4.4 | 0.489 | 5.263 |
| Ethyl alcohol | $C_2H_6O$ | 0.789 | 1,207 | 3,960 | 4.0 | 1.396 | 15.020 |
| Ethyl ben-zene (46) | $C_8H_{10}$ | 0.867 (20°C) | 1,338 (20°C) | 4,389.8 (68°F) | | 0.797 (17°C) | 8.575 (63°F) |
| Ethyl Bromide (46) | $C_2H_5Br$ | 1.461 (20°C) | 900 (20°C) | 2,952.8 (68°F) | | 0.275 (20°C) | 2.959 (68°F) |
| Ethyliodide (46) | $C_2H_5I$ | 1.950 (20°C) | 876 (20°C) | 2874 (68°F) | | 0.29 | 3.12 |
| Ether | $C_4H_{10}O$ | 0.713 | 985 | 3231.6 | 4.87 | 0.311 | 3.346 |
| Ethyl ether | $C_4H_{10}O$ | 0.713 | 985 | 3231.6 | 4.87 | 0.311 | 3.346 |

*Sound Speeds and Pipe Size Data*

## Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Ethylene bromide (47) | $C_2H_4Br_2$ | 2.18 | 995 | 3264.4 | | 0.79 | 8.5 |
| Ethylene chloride (47) | $C_2H_4Cl_2$ | 1.253 | 1,193 | 3914 | | 0.61 | 6.563 |
| Ethylene glycol | $C_2H_6O_2$ | 1.113 | 1,658 | 5439.6 | 2.1 | 17.208 (20°C) | 185.158 (68°F) |
| d-Fenochone | $C_{10}H_{16}O$ | 0.947 | 1,320 | 4330.7 | | 0.22 | 2.367 |
| d-2-Fenecha-none | $C_{10}H_{16}O$ | 0.947 | 1,320 | 4330.7 | | 0.22 | 2.367 |
| Fluorine | F | 0.545 (-143°C) | 403 (-143°C) | 1322.2 (-225°F) | 11.31 | | |
| Fluoro-ben-zene (46) | $C_6H_5F$ | 1.024 (20°C) | 1,189 | 3900.9 | | 0.584 (20°C) | 6.283 (68°F) |
| Formaldehyde, methyl ester | $C_2H_4O_2$ | 0.974 | 1,127 | 3697.5 | 4.02 | | |
| Formamide | $CH_3NO$ | 1.134 (20°C) | 1,622 | 5321.5 | 2.2 | 2.91 | 31.311 |
| Formic acid, amide | $CH_3NO$ | 1.134 (20°C) | 1,622 | 5321.5 | | 2.91 | 31.311 |
| Freon R12 | | | 774.2 | 2540 | | | |
| Furfural | $C_5H_4O_2$ | 1.157 | 1,444 | 4737.5 | 3.7 | | |
| Furfuryl alcohol | $C_5H_6O_2$ | 1.135 | 1,450 | 4757.2 | 3.4 | | |
| Fural | $C_5H_4O_2$ | 1.157 | 1,444 | 4737.5 | 3.7 | | |
| 2-Furalde-hyde | $C_5H_4O_2$ | 1.157 | 1,444 | 4737.5 | 3.7 | | |
| 2-Furancar-boxaldehyde | $C_5H_4O_2$ | 1.157 | 1,444 | 4737.5 | 3.7 | | |
| 2-Furyl-Methanol | $C_5H_6O_2$ | 1.135 | 1,450 | 4757.2 | 3.4 | | |

# Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Gallium | Ga | 6.095 | 2,870 (30°C) | 9416 (86°F) | | | |
| Glycerin | $C_3H_8O_3$ | 1.26 | 1,904 | 6246.7 | 2.2 | 757.1 | 8,081.836 |
| Glycerol | $C_3H_8O_3$ | 1.26 | 1,904 | 6246.7 | 2.2 | 757.1 | 8,081.836 |
| Glycol | $C_2H_6O_2$ | 1.113 | 1658 | 5439.6 | 2.1 | | |
| 50% Glycol / 50% $H_2O$ | | | 1,578 | 5,177 | | | |
| Helium (45) | $He_4$ | 0.125 (-269°C) | 183 (-269°C) | 600.4 (-452°F) | | 0.025 | .269 |
| Heptane (22, 23) | $C_7H_{16}$ | 0.684 (20°C) | 1,131 | 3,710.6 | 4.25 | 0.598 (20°C) | 6.434 (68°F) |
| n-Heptane (29, 33) | $C_7H_{16}$ | 0.684 (20°C) | 1,180 | 3,871.3 | 4.0 | | |
| Hexachloro-Cyclopentadi-ene (47) | $C_5Cl_6$ | 1.7180 | 1,150 | 3,773 | | | |
| Hexadecane (23) | $C_{16}H_{34}$ | 0.773 (20°C) | 1,338 | 4,389.8 | 3.71 | 4.32 (20°C) | 46.483 (68°F) |
| Hexalin | $C_6H_{12}O$ | 0.962 | 1,454 | 4,770.3 | 3.6 | 70.69 (17°C) | 760.882 (63°F) |
| Hexane (16, 22, 23) | $C_6H_{14}$ | 0.659 | 1,112 | 3,648.3 | 2.71 | 0.446 | 4.798 |
| n-Hexane (29, 33) | $C_6H_{14}$ | 0.649 (20°C) | 1,079 | 3,540 | 4.53 | | |
| 2,5-Hex-anedione | $C_6H_{10}O_2$ | 0.729 | 1,399 | 4,589.9 | 3.6 | | |
| n-Hexanol | $C_6H_{14}O$ | 0.819 | 1,300 | 4,265.1 | 3.8 | | |
| Hexahydroben-zene (15) | $C_6H_{12}$ | 0.779 | 1,248 | 4,094.5 | 5.41 | 1.31 (17°C) | 14.095 (63°F) |
| Hexahydro-phenol | $C_6H_{12}O$ | 0.962 | 1,454 | 4,770.3 | 3.6 | | |

*Sound Speeds and Pipe Size Data*

## Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Hexamethyl-ene (15) | $C_6H_{12}$ | 0.779 | 1,248 | 4,094.5 | 5.41 | 1.31 (17°C) | 14.095 (63°F) |
| Hydrogen (45) | $H_2$ | 0.071 (-256°C) | 1,187 (-256°C) | 3,894.4 (-429°F) | | 0.003 (-256°C) | 0.032 (-429°F) |
| 2-Hydroxy-toluene (46) | $C_7H_8O$ | 1.047 (20°C) | 1,541 (20°C) | 5,055.8 (68°F) | | 4.29 (40°C) | 46.16 (104°F) |
| 3-Hydroxy-toluene (46) | $C_7H_8O$ | 1.034 (20°C) | 1,500 (20°C) | 4,921.3 (68°F) | | 5.979 (40°C) | 64.334 (104°F) |
| Iodo-benzene (46) | $C_6H_5I$ | 1.823 | 1,114 (20°C) | 3,654.9 (68°F) | | 0.954 | |
| Iodo-ethane (46) | $C_2H_5I$ | 1.950 (20°C) | 876 (20°C) | 2,874 (68°F) | | 0.29 | 3.12 |
| Iodo-methane | $CH_3I$ | 2.28 (20°C) | 978 | 3,208.7 | | 0.211 | 2.27 |
| Isobutyl acetate (22) | $C_6H_{12}O$ | | 1,180 (27°C) | 3,871.4 (81°F) | 4.85 | | |
| Isobutanol | $C_4H_{10}O$ | 0.81 (20°C) | 1,212 | 3,976.4 | | | |
| Iso-Butane | | | 1,219.8 | 4002 | | | |
| Isopentane (36) | $C_5H_{12}$ | 0.62 (20°C) | 980 | 3,215.2 | 4.8 | 0.34 | 3.658 |
| Isopropanol (46) | $C_3H_8O$ | 0.785 (20°C) | 1,170 (20°C) | 3,838.6 (68°F) | | 2.718 | 29.245 |
| Isopropyl alcohol (46) | $C_3H_8O$ | 0.785 (20°C) | 1,170 (20°C) | 3,838.6 (68°F) | | 2.718 | 29.245 |
| Kerosene | | 0.81 | 1,324 | 4,343.8 | 3.6 | | |
| Ketohexame-thylene | $C_6H_{10}O$ | 0.948 | 1,423 | 4,668.6 | 4.0 | | |
| Lithium fluo-ride (42) | LiF | | 2,485 (900°C) | 8,152.9 (1652°F) | 1.29 | | |
| Mercury (45) | Hg | 13.594 | 1,449 (24°C) | 4,753.9 (75°F) | | 0.114 | 1.226 |

*Sound Speeds and Pipe Size Data*

## Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Mesityloxide | $C_6H_{16}O$ | 0.85 | 1,310 | 4,297.9 | | | |
| Methane (25, 28, 38, 39) | $CH_4$ | 0.162 (-89°C) | 405 (-89°C) | 1,328.7 (-128°F) | 17.5 | | |
| Methanol (40, 41) | $CH_4O$ | 0.791 (20°C) | 1,076 | 3,530.2 | 2.92 | 0.695 | 7.478 |
| Methyl acetate | $C_3H_6O_2$ | 0.934 | 1,211 | 3,973.1 | | 0.407 | 4.379 |
| o-Methyla-niline (46) | $C_7H_9N$ | 0.999 (20°C) | 1,618 | 5,308.4 | | 4.394 (20°C) | 47.279 (68°F) |
| 4-Methyla-niline (46) | $C_7H_9N$ | 0.966 (45°C) | 1,480 | 4,855.6 | | 1.863 (50°C) | 20.095 (122°F) |
| Methyl alco-hol (40, 44) | $CH_4O$ | 0.791 (20°C) | 1,076 | 3,530.2 | 2.92 | 0.695 | 7.478 |
| Methyl ben-zene (16, 52) | $C_7H_8$ | 0.867 | 1,328 (20°C) | 4,357 (68°F) | 4.27 | 0.644 | 7.144 |
| 2-Methyl-butane (36) | $C_5H_{12}$ | 0.62 (20°C) | 980 | 3,215.2 | | 0.34 | 3.658 |
| Methyl carbinol | $C_2H_6O$ | 0.789 | 1,207 | 3,960 | 4.0 | 1.396 | |
| Methyl-chlo-roform (47) | $C_2H_3Cl_3$ | 1.33 | 985 | 3,231.6 | | 0.902 (20°C) | 9.705 (68°F) |
| Methyl-cyanide | $C_2H_3N$ | 0.783 | 1,290 | 4,232.3 | | 0.441 | 4.745 |
| 3-Methyl cyclohexanol | $C_7H_{14}O$ | 0.92 | 1,400 | 4,593.2 | | | |
| Methylene chloride (3) | $CH_2Cl_2$ | 1.327 | 1,070 | 3,510.5 | 3.94 | 0.31 | 3.335 |
| Methylene iodide | $CH_2I_2$ | 3.235 | 980 | 3,215.2 | | | |
| Methyl formate (22) | $C_2H_4O_2$ | 0.974 (20°C) | 1,127 | 3,697.5 | 4.02 | | |

# Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Methyl iodide | CH$_3$I | 2.28 (20°C) | 978 | 3,208.7 | | 0.211 | 2.27 |
| **a**-Methyl naphthalene | C$_{11}$H$_{10}$ | 1.090 | 1,510 | 4,954.1 | 3.7 | | |
| 2-Methylphe-nol (46) | C$_7$H$_8$O | 1.047 (20°C) | 1,541 (20°C) | 5,055.8 (68°F) | | 4.29 (40°C) | 46.16 (104°F) |
| 3-Methylphe-nol (46) | C$_7$H$_8$O | 1.034 (20°C) | 1,500 (20°C) | 4,921.3 (68°F) | | 5.979 (40°C) | 64.334 (104°F) |
| Milk, homog-enized | | | 1,548 | 5,080 | | | |
| Morpholine | C$_4$H$_9$NO | 1.00 | 1,442 | 4,731 | 3.8 | | |
| Naphtha | | 0.76 | 1,225 | 4,019 | | | |
| Natural Gas (37) | | 0.316 (-103°C) | 753 (-103°C) | 2,470.5 (-153°F) | | | |
| Neon (45) | Ne | 1.207 (-246°C) | 595 (-246°C) | 1,952.1 (-411°F) | | | |
| Nitroben-zene (46) | C$_6$H$_5$NO$_2$ | 1.204 (20°C) | 1,415 (20°C) | 4,642.4 (68°F) | | 1.514 | 16.29 |
| Nitrogen (45) | N$_2$ | 0.808 (-199°C) | 962 (-199°C) | 3,156.2 (-326°F) | | 0.217 (-199°C) | 2.334 (-326°F) |
| Nitromethane (43) | CH$_3$NO$_2$ | 1.135 | 1,300 | 4,265.1 | 4.0 | 0.549 | 5.907 |
| Nonane (23) | C$_9$H$_2$O | 0.718 (20°C) | 1,207 | 3,960 | 4.04 | 0.99 (20°C) | 10.652 (68°F) |
| 1-Nonene (27) | C$_9$H$_{18}$ | 0.736 (20°C) | 1,207 | 3,960 | 4.0 | | |
| Octane (23) | C$_8$H$_{18}$ | 0.703 | 1,172 | 3,845.1 | 4.14 | 0.73 | 7.857 |
| n-Octane (29) | C$_8$H$_{18}$ | 0.704 (20°C) | 1,212.5 | 3,978 | 3.50 | 0.737 | .930) |
| 1-Octene (27) | C$_8$H$_{16}$ | 0.723 (20°C) | 1,175.5 | 3,856.6 | 4.10 | | |

## Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Oil of Camphor Sassafrassy | | | 1,390 | 4,560.4 | 3.8 | | |
| Oil, Car (SAE 20a.30) | | 1.74 | 870 | 2,854.3 | | 190 | 2,045.093 |
| Oil, Castor | $C_{11}H_{10}O_{10}$ | 0.969 | 1,477 | 4,845.8 | 3.6 | 0.670 | 7.209 |
| Oil, Diesel | | 0.80 | 1,250 | 4,101 | | | |
| Oil, Fuel AA gravity | | 0.99 | 1,485 | 4,872 | 3.7 | | |
| Oil (Lubricating X200) | | | 1,530 | 5,019.9 | | | |
| Oil (Olive) | | 0.912 | 1,431 | 4,694.9 | 2.75 | 100 | 1,076.365 |
| Oil (Peanut) | | 0.936 | 1,458 | 4,783.5 | | | |
| Oil (Sperm) | | 0.88 | 1,440 | 4,724.4 | | | |
| Oil, 6 | | | 1,509 (22°C) | 4,951 (72°F) | | | |
| 2,2-Oxydiethanol | $C_4H_{10}O_3$ | 1.116 | 1,586 | 5,203.4 | 2.4 | | |
| Oxygen (45) | $O_2$ | 1.155 (-186°C) | 952 (-186°C) | 3,123.4 (-303°F) | | 0.173 | 1.861 |
| Pentachloroethane (47) | $C_2HCl_5$ | 1.687 | 1,082 | 3,549.9 | | | |
| Pentalin (47) | $C_2HCl_5$ | 1.687 | 1,082 | 3,549.9 | | | |
| Pentane (36) | $C_5H_{12}$ | 0.626 (20°C) | 1,020 | 3,346.5 | | 0.363 | 3.905 |
| n-Pentane (47) | $C_5H_{12}$ | 0.557 | 1,006 | 3,300.5 | | 0.41 | 4.413 |
| Perchlorocyclopentadiene (47) | $C_5Cl_6$ | 1.718 | 1,150 | 3,773 | | | |
| Perchloroethylene (47) | $C_2Cl_4$ | 1.632 | 1,036 | 3,399 | | | |

## Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
|---|---|---|---|---|---|---|---|
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Perfluoro-1-Hepten (47) | $C_7F_{14}$ | 1.67 | 583 | 1,912.7 | | | |
| Perfluoro-n-Hexane (47) | $C_6F_{14}$ | 1.672 | 508 | 1,666.7 | | | |
| Phene (29, 40, 41) | $C_6H_6$ | 0.879 | 1,306 | 4,284.8 | 4.65 | 0.711 | 7.65 |
| **b**-Phenyl acrolein | $C_9H_8O$ | 1.112 | 1,554 | 5,098.4 | 3.2 | | |
| Pheny-lamine (41) | $C_6H_5NO_2$ | 1.022 | 1,639 | 5,377.3 | 4.0 | 3.63 | 39.058 |
| Phenyl bromide (46) | $C_6H_5Br$ | 1.522 | 1,170 (20°C) | 3,838.6 (68°F) | | 0.693 | 7.456 |
| Phenyl chloride | $C_6H_5Cl$ | 1.106 | 1,273 | 4,176.5 | 3.6 | 0.722 | 7.768 |
| Phenyl iodide (46) | $C_6H_5I$ | 1.823 | 1,114 (20°C) | 3,654.9 (68°F) | | 0.954 (15°C) | 10.265 (59°F) |
| Phenyl meth-ane (16, 52) | $C_7H_8$ | 0.867 (20°C) | 1,328 (20°C) | 4,357 (68°F) | 4.27 | 0.644 | 6.929 |
| 3-Phenyl propenal | $C_9H_8O$ | 1.112 | 1,554 | 5,098.4 | 3.2 | | |
| Phthalardi-one | $C_8H_4O_3$ | | 1,125 (152°C) | 3,691 (306°F) | | | |
| Phthalic acid, anhydride | $C_8H_4O_3$ | | 1,125 **(152°C)** | 3,691 (306°F) | | | |
| Pthalic anhydride | $C_8H_4O_3$ | | 1,125 (152°C) | 3,691 (306°F) | | | |
| Pimelic ketone | $C_6H_{10}O$ | 0.948 | 1,423 | 4,668.6 | 4.0 | | |
| Plexiglas, Lucite, Acrylic | | | 2,651 | 8,698 | | | |
| Polyterpene Resin | | 0.77 | 1,099.8 (190°C) | 3,608.4 (374°F) | | 39,000 | 419,500 |

## Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10⁻⁶ | |
|---|---|---|---|---|---|---|---|
| | | | All data given at 25°C (77°F) unless otherwise noted. | | | | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m²/s | ft²/s |
| Potassium bromide (42) | KBr | | 1,169 (900°C) | 3,835.3 (1652°F) | 0.71 | .715cp (900°C) | 7.693 (1652°F) |
| Potassium fluoride (42) | KF | | 1,792 (900°C) | 5,879.3 (1652°F) | 1.03 | | |
| Potassium iodide (42) | KI | | 985 (900°C) | 3,231.6 (1652°F) | 0.64 | | |
| Potassium nitrate (48) | $KNO_3$ | 1.859 (352°C) | 1,740.1 (352°C) | 5,709 (666°F) | 1.1 | 1.19 (327°C) | 12.804 (621°F) |
| Propane (2, 13) (-45° to -130°C) | $C_3H_8$ | 0.585 (-45°C) | 1,003 (-45°C) | 3,290.6 (-49°F) | 5.7 | | |
| 1,2,3-Propanetriol | $C_3H_8O_3$ | 1.26 | 1,904 | 6,246.7 | 2.2 | .000757 | |
| 1-Propanol (46) | $C_3H_8O$ | 0.78 (20°C) | 1,222 (20°C) | 4,009.2 (68°F) | | | |
| 2-Propanol (46) | $C_3H_8O$ | 0.785 (20°C) | 1,170 (20°C) | 3,838.6 (68°F) | | 2.718 | 29.245 |
| 2-Propanone | $C_3H_6O$ | 0.791 | 1,174 | 3,851.7 | 4.5 | 0.399 | 4.293 |
| Propene (17, 18, 35) | $C_3H_6$ | 0.563 (-13°C) | 963 (-13°C) | 3,159.4 (9°F) | 6.32 | | |
| n-Propyl acetate (22) | $C_5H_{10}O_2$ | | 1,280 (2°C) | 4,199 (36°F) | 4.63 | | |
| n-Propyl-alcohol | $C_3H_8O$ | 0.78 (20°C) | 1,222 (20°C) | 4,009.2 (68°F) | | 2.549 | 27.427 |
| Propylchloride (47) | $C_3H_7Cl$ | 0.892 | 1,058 | 3,471.1 | | 0.378 | 4.067 |
| Propylene (17, 18, 35) | $C_3H_6$ | 0.563 (-13°C) | 963 (-13°C) | (3159.4) (9°F) | 6.32 | | |
| Pyridine | $C_6H_5N$ | 0.982 | 1,415 | 4,642.4 | 4.1 | 0.992 (20°C) | 10.673 (68°F) |
| Refrigerant 11 (3, 4) | $CCl_3F$ | 1.49 | 828.3 (0°C) | 2,717.5 (32°F) | 3.56 | | |

## Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | All data given at 25°C (77°F) unless otherwise noted. | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| Refrigerant 12 (3) | $CCl_2F_2$ | 1.516 (-40°C) | 774.1 (-40°C) | 2,539.7 (-40°F) | 4.24 | | |
| Refrigerant 14 (14) | $CF_4$ | 1.75 (-150°C) | 875.24 (-150°C) | 2,871.5 (-238°F) | 6.61 | | |
| Refrigerant 21 (3) | $CHCl_2F$ | 1.426 (0°C) | 891 (0°C) | 2,923.2 (32°F) | 3.97 | | |
| Refrigerant 22 (3) | $CHClF_2$ | 1.491 (-69°C) | 893.9 (50°C) | 2,932.7 (122°F) | 4.79 | | |
| Refrigerant 113 (3) | $CCl_2F-CClF_2$ | 1.563 | 783.7 (0°C) | 2,571.2 (32°F) | 3.44 | | |
| Refrigerant 114 (3) | $CClF_2-CClF_2$ | 1.455 | 665.3 (-10°C) | 2,182.7 (14°F) | 3.73 | | |
| Refrigerant 115 (3) | $C_2ClF_5$ | | 656.4 (-50°C) | 2,153.5 (-58°F) | 4.42 | | |
| Refrigerant C318 (3) | $C_4F_8$ | 1.62 (-20°C) | 574 (-10°C) | 1,883.2 (14°F) | 3.88 | | |
| Selenium (8) | Se | | 1,072 (250°C) | 3,517.1 (482°F) | 0.68 | | |
| Silicone (30 cp) | | 0.993 | 990 | 3,248 | | 30 | 322.8 |
| Sodium fluoride (42) | NaF | 0.877 | 2,082 (1000°C) | 6,830.7 (1832°F) | 1.32 | | |
| Sodium nitrate (48) | $NaNO_3$ | 1.884 | 1,763.3 (336°C) | 5,785.1 (637°F) | 0.74 | 1.37 (336°C) | 14.74 (637°F) |
| Sodium nitrite (48) | $NaNO_2$ | 1.805 (292°C) | 1,876.8 (292°C) | 6,157.5 (558°F) | | | |
| Solvesso #3 | | 0.877 | 1,370 | 4,494.8 | 3.7 | | |
| Spirit of wine | $C_2H_6O$ | 0.789 | 1,207 | 3,960 | 4.0 | 1.396 | 15.02 |
| Sulfur (7, 8, 10) | S | | 1,177 (250°C) | 3,861.5 (482°F) | -1.13 | | |
| Sulfuric Acid (1) | $H_2SO_4$ | 1.841 | 1,257.6 | 4,126 | 1.43 | 11.16 | 120.081 |

## Table 2: Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10$^{-6}$ | |
|---|---|---|---|---|---|---|---|
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m$^2$/s | ft$^2$/s |
| | | | All data given at 25°C (77°F) unless otherwise noted. | | | | |
| Tellurium (7) | Te | | 991 (450°C) | 3,251.3 (842°F) | 0.73 | | |
| 1,1,2,2-Tetrabromo-ethane (47) | $C_2H_2Br_4$ | 2.966 | 1,027 | 3,369.4 | | | |
| 1,1,2,2-Tetrachloro-ethane (67) | $C_2H_2Cl_4$ | 1.595 | 1,147 | 3,763.1 | | 1.156 (15°C) | 12.438 (59°F) |
| Tetrachloro-ethane (46) | $C_2H_2Cl_4$ | 1.553 (20°C) | 1,170 (20°C) | 3,838.6 (68°F) | | 1.19 | 12.804 |
| Tetrachloro-ethene (47) | $C_2Cl_4$ | 1.632 | 1,036 | 3,399 | | | |
| Tetrachloro-Methane (33, 47) | $CCl_4$ | 1.595 (20°C) | 926 | 3,038.1 | | 0.607 | 6.531 |
| Tetradecane (46) | $C_{14}H_3O$ | 0.763 (20°C) | 1,331 (20°C) | 4,366.8 (68°F) | | 2.86 (20°C) | 30.773 (68°F) |
| Tetraethyl-ene glycol | $C_8H_{18}O_5$ | 1.123 | 1,586 | 5,203.4 | 3.0 | | |
| Tetrafluoro-methane (14) (Freon 14) | $CF_4$ | 1.75 (-150°C) | 875.24 (-150°C) | 2,871.5 (-238°F) | 6.61 | | |
| Tetrahydro-1,4-isoxazine | $C_4H_9NO$ | 1.000 | 1,442 | 4,731 | 3.8 | | |
| Toluene (16, 52) | $C_7H_8$ | 0.867 (20°C) | 1,328 (20°C) | 4,357 (68°F) | 4.27 | 0.644 | 6.929 |
| o-Toluidine (46) | $C_7H_9N$ | 0.999 (20°C) | 1,618 | 5,308.4 | | 4.394 (20°C) | 47.279 (68°F) |
| p-Toluidine (46) | $C_7H_9N$ | 0.966 (45°C) | 1,480 | 4,855.6 | | 1.863 (50°C) | 20.053 (122°F) |
| Toluol | $C_7H_8$ | 0.866 | 1,308 | 4,291.3 | 4.2 | 0.58 | 6.24 |
| Tribromo-meth-ane (46, 47) | $CHBr_3$ | 2.89 (20°C) | 918 | 3,011.8 | | 0.654 | 7.037 |

## Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | All data given at 25°C (77°F) unless otherwise noted. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Specific Gravity | Sound Speed | | $\frac{\Delta v}{°C}$ | Kinematic Viscosity x10⁻⁶ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | m²/s | ft²/s |
| 1,1,1-Trichloro-ethane (47) | $C_2H_3Cl_3$ | 1.33 | 985 | 3,231.6 | | 0.902 (20°C) | 9.705 (68°F) |
| Trichloro-ethene (47) | $C_2HCl_3$ | 1.464 | 1,028 | 3,372.7 | | | |
| Trichloro-fluoro-romethane (3) (Freon 11) | $CCl_3F$ | 1.49 | 828.3 (0°C) | 2,717.5 (32°F) | 3.56 | | |
| Trichloro-methane (47) | $CHCl_3$ | 1.489 | 979 | 3,211.9 | 3.4 | 0.55 | 5.918 |
| 1,1,2-Trichloro-1,2,2-Trifluoro-Etham | $CCl_2F\text{-}CClF_2$ | 1.563 | 783.7 (0°C) | 2,571.2 (32°F) | | | |
| Triethyl-amine (33) | $C_6H_{15}N$ | 0.726 | 1,123 | 3,684.4 | 4.47 | | |
| Triethylene glycol | $C_6H_{14}O_4$ | 1.123 | 1,608 | 5,275.6 | 3.8 | | |
| 1,1,1-Trifluoro-2-Chloro-2-Bromo-Ethane | $C_2HClBrF_3$ | 1.869 | 693 | 2,273.6 | | | |
| 1,2,2-Trifluorot-richloro-ethane (Freon 113) | $CCl_2F\text{-}CClF_2$ | 1.563 | 783.7 (0°C) | 2,571.2 (32°F) | 3.44 | | |
| d-1,3,3-Trime-thylnorcam-phor | $C_{10}H_{16}O$ | 0.947 | 1,320 | 4,330.7 | | 0.22 | 2.367 |
| Trinitrotolu-ene (43) | $C_7H_5(NO_2)_3$ | 1.64 | 1,610 (81°C) | 5,282.2 (178°F) | | | |
| Turpentine | | 0.88 | 1,255 | 4,117.5 | | 1.4 | 15.064 |
| Unisis 800 | | 0.87 | 1,346 | 4,416 | | | |
| Water, dis-tilled (49, 50) | $H_2O$ | 0.996 | 1,498 | 4,914.7 | -2.4 | 1.00 | 10.76 |
| Water, heavy | $D^2O$ | | 1,400 | 4,593 | | | |
| Water, sea | | 1.025 | 1,531 | 5,023 | -2.4 | 1.00 | 10.76 |

## Table 2:  Sound Speeds in Fluids (cont.)

| Substance | Chemical Formula | Specific Gravity | All data given at 25°C (77°F) unless otherwise noted. | | | | |
| | | | Sound Speed | | $\frac{\Delta \underline{v}}{°C}$ | Kinematic Viscosity x10⁻⁶ | |
| | | | m/s | ft/s | $\frac{m/s}{°C}$ | $m^2/s$ | $ft^2/s$ |
|---|---|---|---|---|---|---|---|
| Wood Alcohol (40, 41) | $CH_4O$ | 0.791 (20°C) | 1,076 | 3,530.2 | 2.92 | 0.695 | 7.478 |
| Xenon (45) | Xe | | 630 (-109°C) | 2,067 (-164°F) | | | |
| m-Xylene (46) | $C_8H_{10}$ | 0.868 (15°C) | 1,343 (20°C) | 4,406.2 (68°F) | | 0.749 (15°C) | 8.059 (59°F) |
| o-Xylene (29, 46) | $C_8H_{10}$ | 0.897 (20°C) | 1,331.5 | 4,368.4 | 4.1 | 0.903 (20°C) | 9.716 (68°F) |
| p-Xylene (46) | $C_8H_{10}$ | | 1,334 (20°C) | 4,376.6 (68°F) | | 0.662 | 7.123 |
| Xylene hexafluoride | $C_8H_4F_6$ | 1.37 | 879 | 2,883.9 | | 0.613 | 6.595 |
| Zinc (7) | Zn | | 3,298 (450°C) | 10,820.2 (842°F) | | | |

**Note:**  *For critical applications, the sources of sound speed data for pure liquids can generally be obtained from Panametrics. Requests for sources must identify temperature and pressure range, and details of liquid composition.*

## Sound Speeds Data (cont.)

The values in Table 3 below are reproduced (with permission) from *American Institute of Physics Handbook,* ©McGraw-Hill Book Co.

**Table 3: Sound Speeds in Water at Selected Temperatures**

| Temper-ature | | Sound Speed in Water | | Temper-ature | | Sound Speed in Water | |
|---|---|---|---|---|---|---|---|
| °C | °F | m/s | ft/s | °C | °F | m/s | ft/s |
| 0 | 32.0 | 1,402 | 4,600 | 23 | 73.4 | 1,491 | 4,892 |
| 1 | 33.8 | 1,407 | 4,616 | 24 | 75.2 | 1,493 | 4,899 |
| 2 | 35.6 | 1,412 | 4,633 | 25 | 77.0 | 1,496 | 4,908 |
| 3 | 37.4 | 1,417 | 4,649 | 26 | 78.8 | 1,499 | 4,918 |
| 4 | 39.2 | 1,421 | 4,662 | 27 | 80.6 | 1,501 | 4,925 |
| 5 | 41.0 | 1,426 | 4,679 | 28 | 82.4 | 1,504 | 4,935 |
| 6 | 42.8 | 1,430 | 4,692 | 29 | 84.2 | 1,506 | 4,941 |
| 7 | 44.6 | 1,434 | 4,705 | 30 | 86.0 | 1,509 | 4,951 |
| 8 | 46.4 | 1,439 | 4,721 | 31 | 87.8 | 1,511 | 4,958 |
| 9 | 48.2 | 1,443 | 4,734 | 32 | 89.6 | 1,513 | 4,964 |
| 10 | 50.0 | 1,447 | 4,748 | 33 | 91.4 | 1,515 | 4,971 |
| 11 | 51.8 | 1,451 | 4,761 | 34 | 93.2 | 1,517 | 4,977 |
| 12 | 53.6 | 1,455 | 4,774 | 35 | 95.0 | 1,519 | 4,984 |
| 13 | 55.4 | 1,458 | 4,784 | 36 | 96.8 | 1,521 | 4,990 |
| 14 | 57.2 | 1,462 | 4,797 | 37 | 98.6 | 1,523 | 4,997 |
| 15 | 59.0 | 1,465 | 4,807 | 38 | 100.4 | 1,525 | 5,004 |
| 16 | 60.8 | 1,469 | 4,820 | 39 | 102.2 | 1,527 | 5,010 |
| 17 | 62.6 | 1,472 | 4,830 | 40 | 104.0 | 1,528 | 5,013 |
| 18 | 64.4 | 1,476 | 4,843 | 41 | 105.8 | 1,530 | 5,020 |
| 19 | 66.2 | 1,479 | 4,853 | 42 | 107.6 | 1,532 | 5,026 |
| 20 | 68.0 | 1,482 | 4,862 | 43 | 109.4 | 1,534 | 5,033 |
| 21 | 69.8 | 1,485 | 4,872 | 44 | 111.2 | 1,535 | 5,036 |
| 22 | 71.6 | 1,488 | 4,882 | 45 | 113.0 | 1,536 | 5,040 |

### Table 3: Sound Speeds in Water at Selected Temperatures (cont.)

| Temper-ature | | Sound Speed in Water | | Temper-ature | | Sound Speed in Water | |
|---|---|---|---|---|---|---|---|
| °C | °F | m/s | ft/s | °C | °F | m/s | ft/s |
| 46 | 114.8 | 1,538 | 5,046 | 74 | 165.2 | 1,555 | 5,102 |
| 47 | 116.6 | 1,539 | 5,049 | 75 | 167.0 | 1,555 | 5,102 |
| 48 | 118.4 | 1,540 | 5,053 | 76 | 168.8 | 1,555 | 5,102 |
| 49 | 120.2 | 1,541 | 5,056 | 77 | 170.6 | 1,554 | 5,099 |
| 50 | 122.0 | 1,543 | 5,063 | 78 | 172.4 | 1,554 | 5,099 |
| 51 | 123.8 | 1,543 | 5,063 | 79 | 174.2 | 1,554 | 5,099 |
| 52 | 125.6 | 1,544 | 5,066 | 80 | 176.0 | 1,554 | 5,099 |
| 53 | 127.4 | 1,545 | 5,069 | 81 | 177.8 | 1,554 | 5,099 |
| 54 | 129.2 | 1,546 | 5,072 | 82 | 179.6 | 1,553 | 5,095 |
| 55 | 131.0 | 1,547 | 5,076 | 83 | 181.4 | 1,553 | 5,095 |
| 56 | 132.8 | 1,548 | 5,079 | 84 | 183.2 | 1,553 | 5,095 |
| 57 | 134.6 | 1,548 | 5,079 | 85 | 185.0 | 1,552 | 5,092 |
| 58 | 136.4 | 1,549 | 5,082 | 86 | 186.8 | 1,552 | 5,092 |
| 59 | 138.2 | 1,550 | 5,086 | 87 | 188.6 | 1,552 | 5,092 |
| 60 | 140.0 | 1,550 | 5,086 | 88 | 190.4 | 1,551 | 5,089 |
| 61 | 141.8 | 1,551 | 5,089 | 89 | 192.2 | 1,551 | 5,089 |
| 62 | 143.6 | 1,552 | 5,092 | 90 | 194.0 | 1,550 | 5,086 |
| 63 | 145.4 | 1,552 | 5,092 | 91 | 195.8 | 1,549 | 5,082 |
| 64 | 147.2 | 1,553 | 5,095 | 92 | 197.6 | 1,549 | 5,082 |
| 65 | 149.0 | 1,553 | 5,095 | 93 | 199.4 | 1,548 | 5,079 |
| 66 | 150.8 | 1,553 | 5,095 | 94 | 201.2 | 1,547 | 5,076 |
| 67 | 152.6 | 1,554 | 5,099 | 95 | 203.0 | 1,547 | 5,076 |
| 68 | 154.4 | 1,554 | 5,099 | 96 | 204.8 | 1,546 | 5,072 |
| 69 | 156.2 | 1,554 | 5,099 | 97 | 206.6 | 1,545 | 5,069 |
| 70 | 158.0 | 1,554 | 5,099 | 98 | 208.4 | 1,544 | 5,066 |
| 71 | 159.8 | 1,554 | 5,099 | 99 | 210.2 | 1,543 | 5,063 |
| 72 | 161.6 | 1,555 | 5,102 | 100 | 212.0 | 1,543 | 5,063 |
| 73 | 163.4 | 1,555 | 5,102 | 104 | 220.0 | 1,538 | 5,046 |

*Sound Speeds and Pipe Size Data*

**Table 3:  Sound Speeds in Water at Selected Temperatures (cont.)**

| Temper-ature | | Sound Speed in Water | | Temper-ature | | Sound Speed in Water | |
|---|---|---|---|---|---|---|---|
| °C | °F | m/s | ft/s | °C | °F | m/s | ft/s |
| 110 | 230.0 | 1,532 | 5,026 | 188 | 370.0 | 1,368 | 4,488 |
| 116 | 240.0 | 1,524 | 5,000 | 193 | 380.0 | 1,353 | 4,439 |
| 121 | 250.0 | 1,526 | 5,007 | 199 | 390.0 | 1,337 | 4,387 |
| 127 | 260.0 | 1,507 | 4,944 | 204 | 400.0 | 1,320 | 4,331 |
| 132 | 270.0 | 1,497 | 4,912 | 210 | 410.0 | 1,302 | 4,272 |
| 138 | 280.0 | 1,487 | 4,879 | 216 | 420.0 | 1,283 | 4,210 |
| 143 | 290.0 | 1,476 | 4,843 | 221 | 430.0 | 1,264 | 4,147 |
| 149 | 300.0 | 1,465 | 4,807 | 227 | 440.0 | 1,244 | 4,082 |
| 154 | 310.0 | 1,453 | 4,767 | 232 | 450.0 | 1,220 | 4,003 |
| 160 | 320.0 | 1,440 | 4,725 | 238 | 460.0 | 1,200 | 3,937 |
| 166 | 330.0 | 1,426 | 4,679 | 243 | 470.0 | 1,180 | 3,872 |
| 171 | 340.0 | 1,412 | 4,633 | 249 | 480.0 | 1,160 | 3,806 |
| 177 | 350.0 | 1,398 | 4,587 | 254 | 490.0 | 1,140 | 3,740 |
| 182 | 360.0 | 1,383 | 4,538 | 260 | 500.0 | 1,110 | 3,642 |

## Pipe Size Data

In Table 4 below:
**A** is ANSI B 36.10 Steel pipe nominal wall thickness designation.
**B** is ANSI B 36.10 Steel pipe schedule numbers.
**C** is ANSI B 36.19 Stainless steel pipe schedule number.

**Table 4:  Std ANSI Data for
Carbon Steel and Stainless Steel Pipe**

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 1/8 | 0.405 | 0.049 | - | - | 10S |
|  |  | 0.068 | STD | 40 | 40S |
|  |  | 0.095 | XS | 80 | 80S |
| 1/4 | 0.540 | 0.065 | - | - | 10S |
|  |  | 0.088 | STD | 40 | 40S |
|  |  | 0.119 | XS | 80 | 80S |
| 3/8 | 0.675 | 0.065 | - | - | 10S |
|  |  | 0.091 | STD | 40 | 40S |
|  |  | 0.126 | XS | 80 | 80S |
| 1/2 | 0.840 | 0.065 | - | - | 5S |
|  |  | 0.083 | - | - | 10S |
|  |  | 0.109 | STD | 40 | 40S |
|  |  | 0.147 | XS | 80 | 80S |
|  |  | 0.187 | - | 160 | - |
|  |  | 0.294 | XXS | - | - |
| 3/4 | 1.050 | 0.065 | - | - | 5S |
|  |  | 0.083 | - | - | 10S |
|  |  | 0.113 | STD | 40 | 40S |
|  |  | 0.154 | XS | 80 | 80S |
|  |  | 0.218 | - | 160 | - |
|  |  | 0.308 | XXS | - | - |

### Table 4:  Std ANSI Data for
### Carbon Steel and Stainless Steel Pipe (cont.)

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 1 | 1.315 | 0.065 | - | - | 5S |
| | | 0.109 | - | - | 10S |
| | | 0.133 | STD | 40 | 40S |
| | | 0.179 | XS | 80 | 80S |
| | | 0.250 | - | 160 | - |
| | | 0.358 | XXS | - | - |
| 1 1/4 | 1.660 | 0.065 | - | - | 5S |
| | | 0.109 | - | - | 10S |
| | | 0.140 | STD | 40 | 40S |
| | | 0.191 | XS | 80 | 80S |
| | | 0.250 | - | 160 | - |
| | | 0.382 | XXS | - | - |
| 1 1/2 | 1.900 | 0.065 | - | - | 5S |
| | | 0.109 | - | - | 10S |
| | | 0.145 | STD | 40 | 40S |
| | | 0.200 | XS | 80 | 80S |
| | | 0.281 | - | 160 | - |
| | | 0.400 | XXS | - | - |
| 2 | 2.375 | 0.065 | - | - | 5S |
| | | 0.109 | - | - | 10S |
| | | 0.154 | STD | 40 | 40S |
| | | 0.218 | XS | 80 | 80S |
| | | 0.344 | - | 160 | - |
| | | 0.436 | XXS | - | - |
| 2 1/2 | 2.875 | 0.083 | - | - | 5S |
| | | 0.120 | - | - | 10S |
| | | 0.203 | STD | 40 | 40S |
| | | 0.276 | XS | 80 | 80S |
| | | 0.375 | - | 160 | - |
| | | 0.552 | XXS | - | - |

## Table 4: Std ANSI Data for
## Carbon Steel and Stainless Steel Pipe (cont.)

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 3 | 3.500 | 0.083 | - | - | 5S |
| | | 0.120 | - | - | 10S |
| | | 0.216 | STD | 40 | 40S |
| | | 0.300 | XS | 80 | 80S |
| | | 0.438 | - | 160 | - |
| | | 0.600 | XXS | - | - |
| 3 1/2 | 4.000 | 0.083 | - | - | 5S |
| | | 0.120 | - | - | 10S |
| | | 0.226 | STD | 40 | 40S |
| | | 0.318 | XS | 80 | 80S |
| | | 0.636 | XXS | | - |
| 4 | 4.500 | 0.083 | - | - | 5S |
| | | 0.120 | - | - | 10S |
| | | 0.237 | STD | 40 | 40S |
| | | 0.337 | XS | 80 | 80S |
| | | 0.438 | - | 120 | - |
| | | 0.531 | - | 160 | - |
| | | 0.674 | XXS | - | - |
| 5 | 5.536 | 0.109 | - | - | 5S |
| | | 0.134 | - | - | 10S |
| | | 0.258 | STD | 40 | 40S |
| | | 0.375 | XS | 80 | 80S |
| | | 0.500 | - | 120 | - |
| | | 0.625 | - | 160 | - |
| | | 0.750 | XXS | - | - |

## Table 4: Std ANSI Data for
## Carbon Steel and Stainless Steel Pipe (cont.)

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 6 | 6.625 | 0.109 | - | - | 5S |
| | | 0.134 | - | - | 10S |
| | | 0.280 | STD | 40 | 40S |
| | | 0.432 | XS | 80 | 80S |
| | | 0.562 | - | 120 | - |
| | | 0.719 | - | 160 | - |
| | | 0.864 | XXS | - | - |
| 8 | 8.625 | 0.109 | - | - | 5S |
| | | 0.148 | - | - | 10S |
| | | 0.250 | - | 20 | - |
| | | 0.277 | - | 30 | - |
| | | 0.322 | STD | 40 | 40S |
| | | 0.406 | - | 60 | - |
| | | 0.500 | XS | 80 | 80S |
| | | 0.594 | - | 100 | - |
| | | 0.719 | - | 120 | - |
| | | 0.812 | - | 140 | - |
| | | 0.875 | XXS | - | - |
| | | 0.906 | - | 160 | - |
| 10 | 10.750 | 0.134 | - | - | 5S |
| | | 0.165 | - | - | 10S |
| | | 0.250 | - | 20 | - |
| | | 0.307 | - | 30 | - |
| | | 0.365 | STD | 40 | 40S |
| | | 0.500 | XS | 60 | 80S |
| | | 0.594 | - | 80 | - |
| | | 0.719 | - | 100 | - |
| | | 0.844 | - | 120 | - |
| | | 1.000 | XXS | 140 | - |

## Table 4: Std ANSI Data for
## Carbon Steel and Stainless Steel Pipe (cont.)

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 12 | 12.750 | 0.156 | - | - | 5S |
| | | 0.180 | - | - | 10S |
| | | 0.250 | - | 20 | - |
| | | 0.330 | - | 30 | - |
| | | 0.375 | STD | - | 40S |
| | | 0.406 | - | 40 | - |
| | | 0.500 | XS | - | 80S |
| | | 0.562 | - | 60 | - |
| | | 0.688 | - | 80 | - |
| | | 0.844 | - | 100 | - |
| | | 1.000 | XXS | 120 | - |
| | | 1.125 | - | 140 | - |
| | | 1.312 | - | 160 | - |
| 14 | 14.000 | 0.156 | - | - | 5S |
| | | 0.188 | - | - | 10S |
| | | 0.250 | - | 10 | - |
| | | 0.312 | - | 20 | - |
| | | 0.375 | STD | 30 | - |
| | | 0.438 | - | 40 | - |
| | | 0.500 | XS | - | - |
| | | 0.594 | - | 60 | - |
| | | 0.625 | XXS | - | - |
| | | 0.750 | - | 80 | - |
| | | 0.938 | - | 100 | - |
| | | 1.094 | - | 120 | - |
| | | 1.250 | - | 140 | - |
| | | 1.406 | - | 160 | - |

## Table 4:  Std ANSI Data for
## Carbon Steel and Stainless Steel Pipe (cont.)

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 16 | 16.000 | 0.165 | - | - | 5S |
|  |  | 0.188 | - | - | 10S |
|  |  | 0.250 | - | 10 | - |
|  |  | 0.312 | - | 20 | - |
|  |  | 0.375 | STD | 30 | - |
|  |  | 0.500 | XS | 40 | - |
|  |  | 0.656 | - | 60 | - |
|  |  | 0.844 | - | 80 | - |
|  |  | 1.031 | - | 100 | - |
|  |  | 1.219 | - | 120 | - |
|  |  | 1.439 | - | 140 | - |
|  |  | 1.594 | - | 160 | - |
| 18 | 18.000 | 0.165 | - | - | 5S |
|  |  | 0.188 | - | - | 10S |
|  |  | 0.250 | - | 10 | - |
|  |  | 0.312 | - | 20 | - |
|  |  | 0.375 | STD | - | - |
|  |  | 0.438 | - | 30 | - |
|  |  | 0.500 | XS | - | - |
|  |  | 0.562 | - | 40 | - |
|  |  | 0.750 | - | 60 | - |
|  |  | 0.938 | - | 80 | - |
|  |  | 1.156 | - | 100 | - |
|  |  | 1.375 | - | 120 | - |
|  |  | 1.562 | - | 140 | - |
|  |  | 1.781 | - | 160 | - |

### Table 4:  Std ANSI Data for
### Carbon Steel and Stainless Steel Pipe (cont.)

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 20 | 20.000 | 0.188 | - | - | 5S |
| | | 0.218 | - | - | 10S |
| | | 0.250 | - | 10 | - |
| | | 0.375 | STD | 20 | - |
| | | 0.500 | XS | 30 | - |
| | | 0.594 | - | 40 | - |
| | | 0.812 | - | 60 | - |
| | | 1.031 | - | 80 | - |
| | | 1.281 | - | 100 | - |
| | | 1.500 | - | 120 | - |
| | | 1.750 | - | 140 | - |
| | | 1.969 | - | 160 | - |
| 22 | 22.000 | 0.188 | - | - | 5S |
| | | 0.218 | - | - | 10S |
| | | 0.250 | - | 10 | - |
| | | 0.375 | STD | 20 | - |
| | | 0.500 | XS | 30 | - |
| | | 0.875 | - | 60 | - |
| | | 1.125 | - | 80 | - |
| | | 1.375 | - | 100 | - |
| | | 1.625 | - | 120 | - |
| | | 1.875 | - | 140 | - |
| | | 2.125 | - | 160 | - |

### Table 4:  Std ANSI Data for
### Carbon Steel and Stainless Steel Pipe (cont.)

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | A Carbon Steel Wall Thickness | B Carbon Steel Schedule Number | C Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 24 | 24.000 | 0.218 | - | - | 5S |
|  |  | 0.250 | - | 10 | 10S |
|  |  | 0.375 | STD | 20 | - |
|  |  | 0.500 | XS | - | - |
|  |  | 0.562 | - | 30 | - |
|  |  | 0.688 | - | 40 | - |
|  |  | 0.969 | - | 60 | - |
|  |  | 1.219 | - | 80 | - |
|  |  | 1.531 | - | 100 | - |
|  |  | 1.812 | - | 120 | - |
|  |  | 2.062 | - | 140 | - |
|  |  | 2.344 | - | 160 | - |
| 26 | 26.000 | 0.312 | - | 10 | - |
|  |  | 0.375 | STD | - | - |
|  |  | 0.500 | XS | 20 | - |
| 28 | 28.000 | 0.312 | - | 10 | - |
|  |  | 0.375 | STD | - | - |
|  |  | 0.500 | XS | 20 | - |
|  |  | 0.625 | - | 30 | - |
| 30 | 30.000 | 0.250 | - | - | 5S |
|  |  | 0.312 | - | 10 | 10S |
|  |  | 0.375 | STD | - | - |
|  |  | 0.500 | XS | 20 | - |
|  |  | 0.625 | - | 30 | - |
|  |  | 0.750 | - | 40 | - |
| 32 | 32.000 | 0.312 | - | 10 | - |
|  |  | 0.375 | STD | - | - |
|  |  | 0.500 | XS | 20 | - |
|  |  | 0.625 | - | 30 | - |
|  |  | 0.688 | - | 40 | - |

**Table 4:  Std ANSI Data for
Carbon Steel and Stainless Steel Pipe (cont.)**

| Nominal Pipe Size (in.) | Outside Diameter (in.) | Wall Thickness (in.) | **A** Carbon Steel Wall Thickness | **B** Carbon Steel Schedule Number | **C** Stainless Steel Schedule Number |
|---|---|---|---|---|---|
| 34 | 34.000 | 0.344 | - | 10 | - |
|  |  | 0.375 | STD | - | - |
|  |  | 0.500 | XS | 20 | - |
|  |  | 0.625 | - | 30 | - |
|  |  | 0.688 | - | 40 | - |
| 36 | 36.000 | 0.312 | - | 10 | - |
|  |  | 0.375 | STD | - | - |
|  |  | 0.500 | XS | 20 | - |
|  |  | 0.625 | - | 30 | - |
|  |  | 0.750 | - | 40 | - |
| 42 | 42.000 | 0.375 | STD | - | - |
|  |  | 0.500 | XS | 20 | - |
|  |  | 0.625 | - | 30 | - |
|  |  | 0.750 | - | 40 | - |
| 48 | 48.000 | 0.375 | STD | - | - |
|  |  | 0.500 | XS | - | - |

## Table 5: Cast Iron Pipe Data - Standard Classes

| Nom. Pipe Size (in.) | Class A | | Class B | | Class C | | Class D | |
|---|---|---|---|---|---|---|---|---|
| | O.D. (in.) | Wall Thk. (in.) | O.D. (in.) | Wall Thk. (in.) | O.D. (in.) | Wall Thk. (in.) | O.D. (in.) | Wall Thk. (in.) |
| 3 | 3.80 | 0.39 | 3.96 | 0.42 | 3.96 | 0.45 | 3.96 | 0.48 |
| 4 | 4.80 | 0.42 | 5.00 | 0.45 | 5.00 | 0.40 | 5.00 | 0.52 |
| 6 | 6.90 | 0.44 | 7.10 | 0.48 | 7.10 | 0.51 | 7.10 | 0.55 |
| 8 | 9.05 | 0.46 | 9.05 | 0.51 | 9.30 | 0.56 | 9.30 | 0.60 |
| 10 | 11.10 | 0.50 | 11.10 | 0.57 | 11.40 | 0.62 | 11.40 | 0.68 |
| 12 | 13.20 | 0.54 | 13.20 | 0.62 | 13.50 | 0.68 | 13.50 | 0.75 |
| 14 | 15.30 | 0.57 | 15.30 | 0.66 | 15.65 | 0.74 | 15.65 | 0.82 |
| 16 | 7.40 | 0.60 | 17.40 | 0.70 | 17.80 | 0.80 | 17.80 | 0.89 |
| 18 | 19.50 | 0.64 | 19.50 | 0.75 | 19.92 | 0.87 | 19.92 | 0.96 |
| 20 | 21.60 | 0.67 | 21.60 | 0.80 | 22.06 | 0.92 | 22.06 | 1.03 |
| 24 | 25.80 | 0.76 | 25.80 | 0.89 | 26.32 | 1.05 | 26.32 | 1.16 |
| 30 | 31.74 | 0.88 | 32.00 | 1.03 | 32.40 | 1.20 | 32.74 | 1.37 |
| 32 | 37.96 | 0.99 | 38.30 | 1.15 | 38.70 | 1.36 | 39.16 | 1.58 |
| 42 | 44.20 | 1.10 | 44.50 | 1.28 | 45.10 | 1.54 | 45.58 | 1.78 |
| 48 | 50.50 | 1.26 | 50.80 | 1.42 | 51.40 | 1.71 | 51.98 | 1.99 |
| 54 | 56.66 | 1.35 | 57.10 | 1.55 | 57.80 | 1.90 | 58.40 | 2.23 |
| 60 | 62.80 | 1.39 | 63.40 | 1.67 | 64.20 | 2.00 | 64.82 | 2.38 |
| 72 | 75.34 | 1.62 | 76.00 | 1.95 | 76.88 | 2.39 | | |
| 84 | 87.54 | 1.72 | 88.54 | 2.22 | | | | |

**Table 5:   Cast Iron Pipe Data - Standard Classes (cont.)**

| Nom. Pipe Size (in.) | Class E | | Class F | | Class G | | Class H | |
|---|---|---|---|---|---|---|---|---|
| | O.D. (in.) | Wall Thk. (in.) | O.D. (in.) | Wall Thk. (in.) | O.D. (in.) | Wall Thk. (in.) | O.D. (in.) | Wall Thk. (in.) |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 6 | 7.22 | 0.58 | 7.22 | 0.61 | 7.38 | 0.65 | 7.38 | 0.69 |
| 8 | 9.42 | 0.66 | 9.42 | 0.66 | 9.60 | 0.75 | 9.60 | 0.80 |
| 10 | 11.60 | 0.74 | 11.60 | 0.80 | 11.84 | 0.86 | 11.84 | 0.92 |
| 12 | 13.78 | 0.82 | 13.78 | 0.89 | 14.08 | 0.97 | 14.08 | 1.04 |
| 14 | 15.98 | 0.90 | 15.98 | 0.99 | 16.32 | 1.07 | 16.32 | 1.16 |
| 16 | 18.16 | 0.90 | 18.16 | 1.08 | 18.54 | 1.18 | 18.54 | 1.27 |
| 18 | 20.34 | 1.07 | 20.34 | 1.17 | 20.78 | 1.28 | 20.78 | 1.39 |
| 20 | 22.54 | 1.15 | 22.54 | 1.27 | 23.02 | 1.39 | 23.02 | 1.51 |
| 24 | 26.90 | 1.31 | 26.90 | 1.45 | 27.76 | 1.75 | 27.76 | 1.88 |
| 30 | 33.10 | 1.55 | 33.46 | 1.73 | | | | |
| 32 | 39.60 | 1.80 | 40.04 | 2.02 | | | | |
| 42 | | | | | | | | |
| 48 | | | | | | | | |
| 54 | | | | | | | | |
| 60 | | | | | | | | |
| 72 | | | | | | | | |
| 84 | | | | | | | | |

## Table 6:  Ductile Iron Pipe Data - Standard Classes

| Nom. Pipe Size (in.) | O.D. (in.) | Pipe Wall Thickness (in.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Class 50 | Class 51 | Class 52 | Class 53 | Class 54 | Class 55 | Class 56 |
| 3 | 3.96 | | 0.25 | 0.28 | 0.31 | 0.43 | 0.37 | 0.40 |
| 4 | 4.80 | | 0.26 | 0.29 | 0.32 | 0.35 | 0.38 | 0.41 |
| 6 | 6.90 | 0.25 | 0.28 | 0.31 | 0.34 | 0.37 | 0.40 | 0.43 |
| 8 | 9.05 | 0.27 | 0.30 | 0.33 | 0.36 | 0.39 | 0.42 | 0.45 |
| 10 | 11.10 | 0.29 | 0.32 | 0.35 | 0.38 | 0.44 | 0.47 | |
| 12 | 13.20 | 0.31 | 0.34 | 0.37 | 0.40 | 0.43 | 0.46 | 0.49 |
| 14 | 15.30 | 0.33 | 0.36 | 0.39 | 0.42 | 0.45 | 0.48 | 0.51 |
| 16 | 17.40 | 0.34 | 0.37 | 0.40 | 0.43 | 0.46 | 0.49 | 0.52 |
| 18 | 19.50 | 0.35 | 0.38 | 0.41 | 0.44 | 0.47 | 0.50 | 0.53 |
| 20 | 21.60 | 0.36 | 0.39 | 0.42 | 0.45 | 0.48 | 0.51 | 0.54 |
| 24 | 25.80 | 0.38 | 0.41 | 0.44 | 0.47 | 0.50 | 0.53 | 0.56 |
| 30 | 32.00 | | | | 0.51 | 0.55 | 0.59 | 0.63 |
| 36 | 38.30 | | | | 0.58 | 0.63 | 0.68 | 0.73 |
| 42 | 44.50 | | | | 0.65 | 0.71 | 0.77 | 0.83 |
| 48 | 50.80 | | | | 0.72 | 0.79 | 0.86 | 0.93 |
| 54 | 57.10 | | | | 0.81 | 0.89 | 0.97 | 1.05 |

# Appendix C

# Calculating P and L Dimensions

If you are using wetted transducers, the TransPort requires that you enter the path length (P) and the axial dimension (L). P is the transducer face-to-face distance and L is the axial projection of P in the flow stream.

To determine L, physically measure the distance between the center of the transducer ports at the inside wall as shown in Figure C-1 below, if possible. If not, consult the factory.
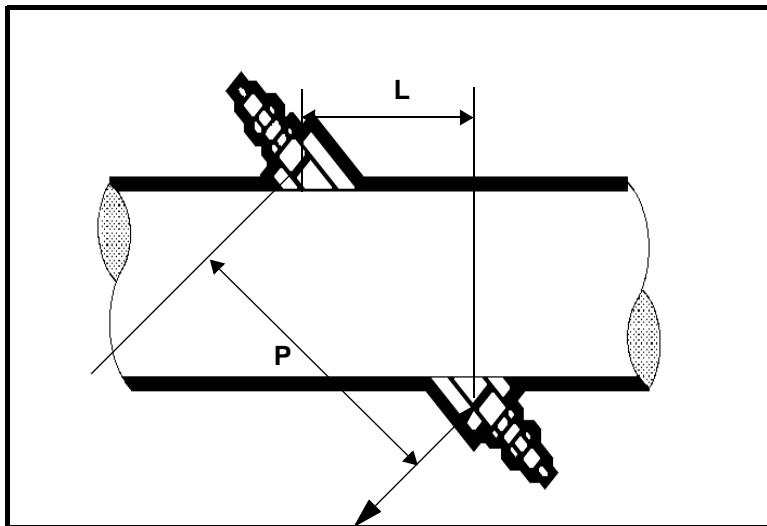


**Figure C-1:  P and L Dimension**

# Calculating P and L Dimensions (cont.)

To determine P, you need the following:

- the pipe inside diameter (ID)

- the wall thickness (WT)

- the installed pipe coupling length (CL)

- the transducer face depth (FD)

- the mounting angle (MA)

Use Figure C-2 below to properly measure the coupling length. Typically, the transducer face is positioned just outside the inside diameter (ID) of the pipe, or slightly retracted inside the coupling.
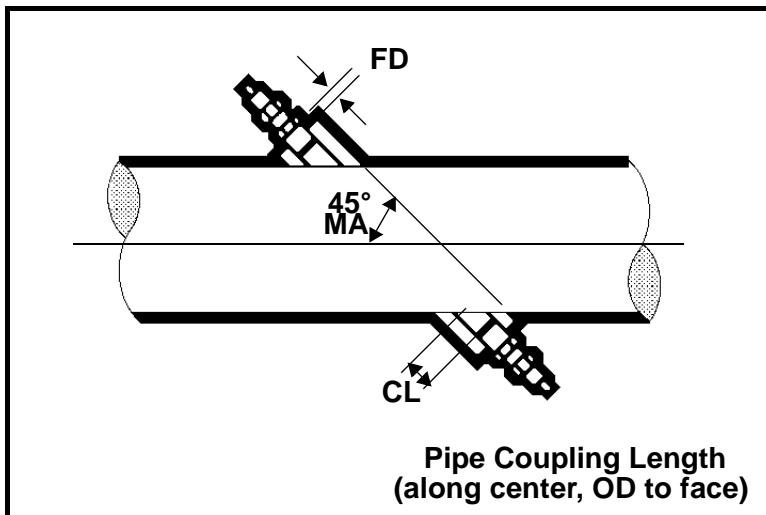


**Figure C-2: Determining the Pipe Coupling Length**

# Calculating P and L Dimensions (cont.)

Use the following formula to determine the P dimension:

[ID + 2(WT)]/(cos MA) + 2(CL - FD) = P Dimension

For example, given the following:

- inside diameter (ID) = 48 in.

- wall thickness (WT) = 3/8 in.

- installed coupling length (CL) = 2.0 in.

- a transducer face depth (FD) = 1.75 in.

- mounting angle (MA) = 45°

The P dimension would be
[48 + 2(3/8)]/(0.7071) + 2(2.0 - 1.75) = 69.4 in.

# Appendix D

# Serial Connections

The TransPort can transmit stored data and displayed readings using the RS232 communication port.To connect the serial device to the TransPort, you must use the proper cable.  Panametrics provides the following cables, which are compatible with most computer or serial devices (see Table D-1 below).

**Table D-1:  Serial Port Cables**

| Cable Part # | Connector Description | Cable Length | Typical Device |
|---|---|---|---|
| 26DLC/9F-6 | "D" Type, 9 pin female contacts | 1.8 m (6 ft) 3.6 m (12 ft) optional | IBM or compatible AT or PS2-30 computer |
| 26DLC/25F-6 | "D" Type, 25 pin female contacts | 1.8 m (6 ft) 3.6 m (12 ft) optional | PC, PC-XT, and PS-2 type computers, some serial printers |
| 26DLC/25M-6 | "D" Type, 25 male | 1.8 m (6 ft) 3.6 m (12 ft) optional | Other computer (socket) contacts and serial printer |
| 26DLC/X-12 | Cable has no connector | 3.6 m (12 ft) | For custom do it yourself cables |

# Appendix E
# Temperature Transmitter Installation

The TransPort requires a supply and return temperature input to measure energy rate and consumption. You must connect the temperature sensors to a 4 to 20-mA transmitter (powered by the TransPort or externally) and then from the transmitter to the TransPort (a special Panametrics cable is required to make transmitter to TransPort connections).

Panametrics can supply the Resistive Temperature Device (RTD) and a Dual Transmitter (DTR) or you may supply your own. If you supply your own equipment, you will need to order a special Panametrics cable with a LEMO connector to make connections from the transmitter to the TransPort.

To install the RTDs, you need to do the following:

- find a suitable installation site

- mount RTDs on the pipe

- make electrical connections

Use the instructions that follow to install the RTDs.

# Guidelines for RTD Installation

You should have discussed possible installation sites with an applications engineer or field sales person by the time you receive the RTDs. However, you should follow these guidelines to ensure accurate temperature measurement:

- Do not install the RTD on a pipe seam.

- Clean the pipe at the installation location.

- Do not install the RTD on the top or the bottom of the pipe.

- Apply thermal couplant to the RTD before mounting it to the pipe.

- Insulate the pipe and RTD after installation.

If you have a Panametrics RTD, use the instructions in the next section to properly mount the RTD on the pipe.

# Mounting RTDs to the Pipe

Panametrics supplies a clamping fixture to mount the RTDs to the pipe; however, you must assemble the clamping fixture before you can mount the RTDs. Use the following instructions to assemble the clamping fixture and mount the RTDs.

## Assembling the Clamping Fixture

The clamping fixture consists of the following parts:

- one strap (length depends on the pipe size)
- a screw buckle
- a feeder buckle

To assemble the clamping fixture:

**1.** Cut the strap equal to the circumference of the pipe.

**2.** Fold a half inch of one end of the strap into a hook shape.

**3.** Secure the screw buckle to one end of the strap by placing the strap through the buckle and folding the strap.

## Assembling the Clamping Fixture (cont.)

**4.** Crimp the strap closed to secure the screw buckle in place.

**5.** Each RTD has a securing post (located on the rounded portion of the RTD) that secures the RTD in place when it is mounted on the pipe. Place the RTD on the strap by sliding the strap under the securing post.

**Note:** *Be sure to place the RTD on the strap so that the flat surface of the RTD will sit against the pipe.*

**6.** Secure the feeder buckle to the other end of the strap by placing the strap through the buckle and folding the strap (the folded section should be approximately 1/2 inch).

**7.** Crimp the strap closed to secure the feeder buckle in place.

Repeat steps 1 through 7 for the remaining RTD and clamping fixture. When you have completed assembly, proceed to the next section to fasten the RTD to the pipe.

## Mounting the RTDs

Use the steps below to fasten the RTDs to the pipe:

**1.** Prepare the area of the pipe where you intend to place the RTD; it should be clean and free of loose material.

**2.** Apply couplant (Panametrics part number 401-001) to the copper face of the RTD. Use enough couplant to cover the face of RTD, but not so much that the couplant oozes out from underneath.

**3.** Position the RTD on the pipe and wrap the clamping fixture around the pipe.

**4.** To secure the RTD, place the feeder buckle into the screw buckle and use a screw driver to tighten. Turn the screw clockwise until the strap is set securely against the RTD.

Proceed to the following section to make electrical connections.

# Making Electrical Connections

The TransPort will not accept a signal directly from the RTD; therefore, you must have some type of 4 to 20-mA transmitter. Panametrics supplies a dual transmitter (DTR) with a special LEMO connector that attaches to the TransPort. The TransPort supplies power to the DTR using an internal 16 V supply. If you decide to supply your own transmitter, you can use the 16 V supply to power your transmitter; however, you will need to order the special LEMO connector cable to connect your transmitter to the TransPort.

To make electrical connections you must connect the RTD sensor to the 4 to 20-mA transmitter and then connect the DTR to the TransPort. Use the following sections to make electrical connections.

## Connecting the RTD to the 4 to 20-mA Transmitter

RTDs should have two common leads and one signal lead. If you are using a Panametrics RTD, the wire colors may vary; however, two of the RTD wires will be the same color. The wires that are the same color are the common leads and the remaining wire is the signal lead.

If you are using your own transmitter, make the necessary connections. If you are using the Panametrics DTR, connect the RTD wires to the terminal block labeled RTD Inputs. Connect the common and signal wires to the appropriate pins as designated on the terminal block label.

**Note:** *The supply and return RTD cables must be the same length in order to make accurate temperature measurements.*

When you have completed supply and return connections, proceed to the next section.

## Connecting the Transmitter to the TransPort

If you are using the Panametrics DTR, simply plug the LEMO connector into the ANALOG I/O connector as shown in Figure E-1 below. If you are using your own transmitter, you must connect the special Panametrics cable to your transmitter as shown in Table E-1 on page E-6.
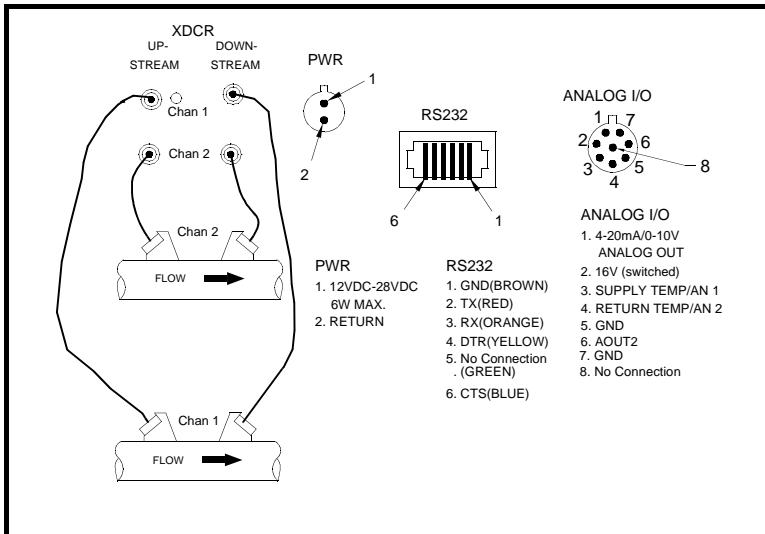


**Figure E-1: Connection Locations**

Connecting the Transmitter to the TransPort (cont.)

**Table E-1: Cable Connections from Panametrics Cable to Customer-Supplied Transmitter**

| Pin Number on Panametrics Cable | Wire Color on Panametrics Cable | Description |
|---|---|---|
| 2 | Red | 16 V (for unpowered transmitters only) |
| 3 | White | Supply Temperature |
| 4 | Yellow | Return Temperature |
| 5 | Green | Ground (for both supply and return) |

Once you complete making the above connection, plug the LEMO connector into the ANALOG I/O connector as shown in Figure E-1 above. You have completed RTD installation.

# Appendix F

# Menu Maps

This appendix contains menu maps for each of the TransPort functions as follows:

- PROG — enables you to enter channel data into the Program Menu.

- PRINT — enables you to print stored and displayed data.

- LOG — enables you to log data.

- DISP — enables you to set up the screen to display measurements in text or graph form.

- CLR — enables you to clear log, channel and totals.

- CAL — enables you to calibrate the analog inputs and outputs, as well as to use the optional ultrasonic thickness gauge.

Use these maps as a guide to entering and exiting each menu.
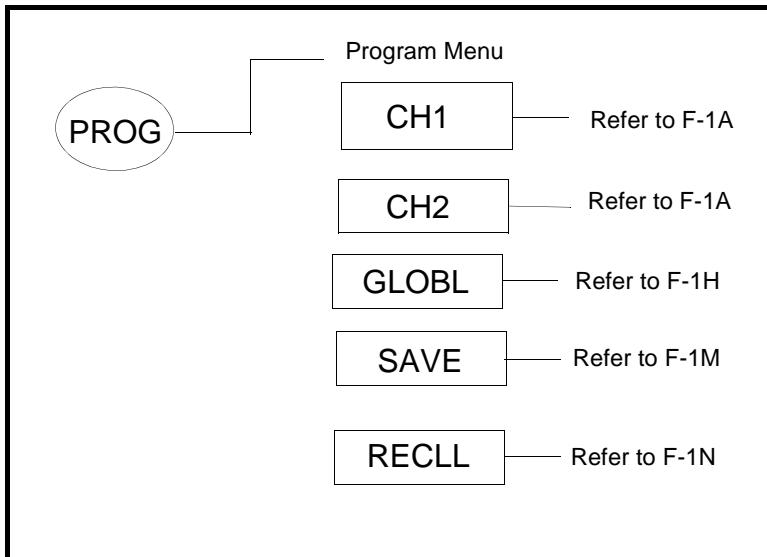
**Figure F-1: PROGram Menu**
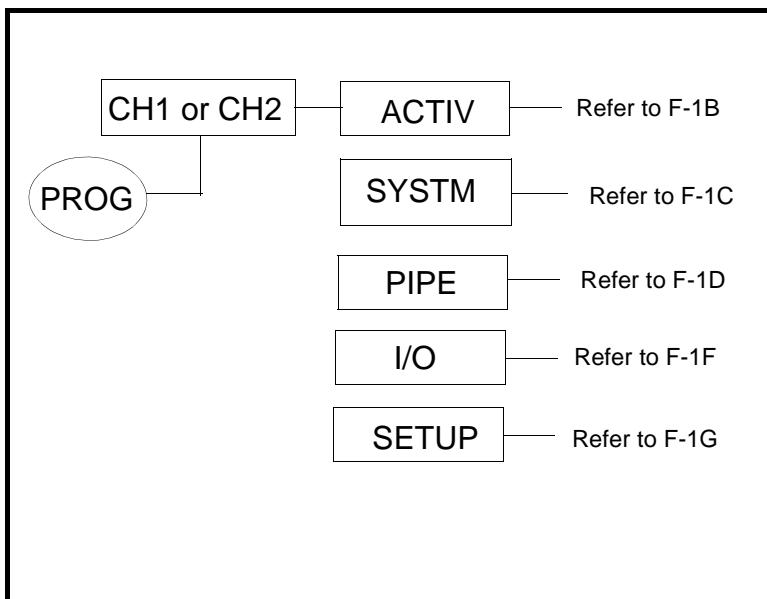


**Figure F-1A: PROGram Menu CHANNEL Options**
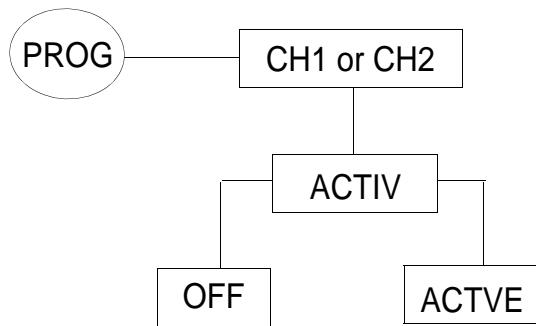
**Figure F-1B:  PROG CHANNEL ACTIV Options**

PROG — CH1 or CH2

SYSTM — Energy Option

Channel Label

Channel Message

Volumetric Units

Vol Decimal Digits

Totalizer Units

Total Decimal Digits

Power — If the Energy Option is On

Power Decimal Digits

Energy (Total)

Energy Decimal Digits

Heating or Cooling — EXIT
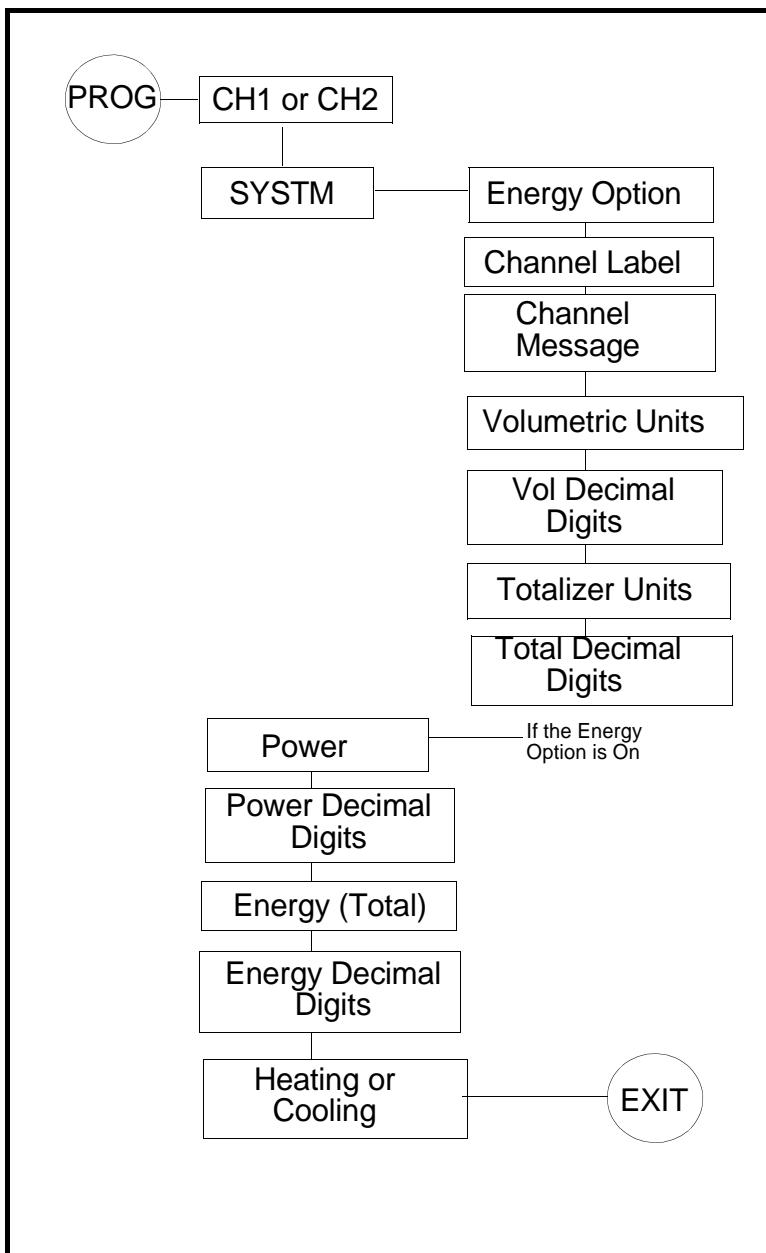
**Figure F-1C: PROG CHANNEL SYSTM Options**

CH1 or CH2 — PIPE — Transducer #

If you are using clamp-on or wetted

PROG

Wedge Temp Input (for med. + high temp.)

Pipe Material — Pipe O.D.

Pipe Wall

Lining

If you are using clamp-on or wetted — Path Length P

Lining Material

Axial Length L

Lining Thickness

Fluid Type

Reynolds Correction

If you are using clamp-on or wetted

Kin. Viscosity

Only appears if Reynolds Correction is enabled

Calibration Factor

Kin. Viscosity

Only appears if Reynolds Correction is enabled

# of Traverses

Transducer Spacing

EXIT

Calibration Factor

**Figure F-1D: PROG CHANNEL PIPE Options for Standard Clamp-On and Wetted Transducers**

CH1 or CH2 — PIPE — Transducer #

Press [F1] to select SPEC.

PROG

Special Transducer #

Wedge Type

Frequency

Tw

If you are using clamp-on or wetted

Wedge Angle

Wedge Sound Speed

Pipe Material — Pipe O.D.

Pipe Wall

If you are using clamp-on or wetted

Lining — Path Length P

Lining Material

Axial Length L

Lining Thickness

Fluid Type

Reynolds Correction

Kin. Viscosity

Only appears if Reynolds Correction is enabled

Calibration Factor

If you are using clamp-on or wetted

# of Traverses

Transducer Spacing

EXIT

**Figure F-1E:  PROG CHANNEL PIPE Options for Special Clamp-On and Wetted Transducers**

```
                    ┌─────────┐
                    │  PROG   │
                    └─────────┘
                         │
                ┌─────────────────┐
                │  CH1 or CH2     │
                └─────────────────┘
                         │
                     ┌───────┐
                     │  I/O  │
                     └───────┘
                         │
                ┌─────────────────┐
                │  Zero Cutoff    │
                └─────────────────┘

                    If Energy was
                       chosen

             ┌─────────────────────┐
             │   Temp Input        │
             │   Supply            │
             └─────────────────────┘

                 Fixed or Active

      ┌─────────────────┐
      │  Temperature    │
      └─────────────────┘

                         ┌─────────────────┐
                         │  Temp Input     │
                         │  Return         │
                         └─────────────────┘

                     Fixed or Active

      ┌─────────────────┐
      │  Temperature    │
      └─────────────────┘
                             ┌─────────┐
                             │  EXIT   │
                             └─────────┘
```
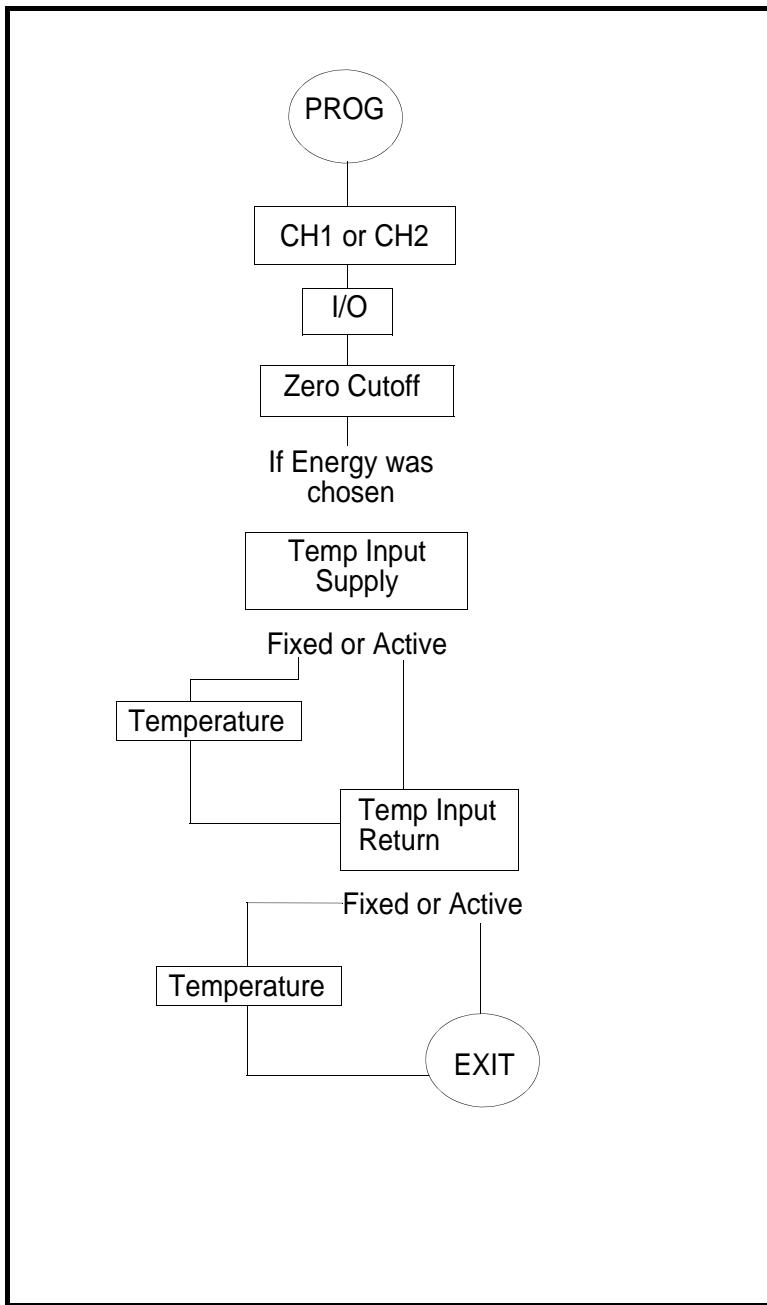
**Figure F-1F:  PROG CHANNEL I/O Options**
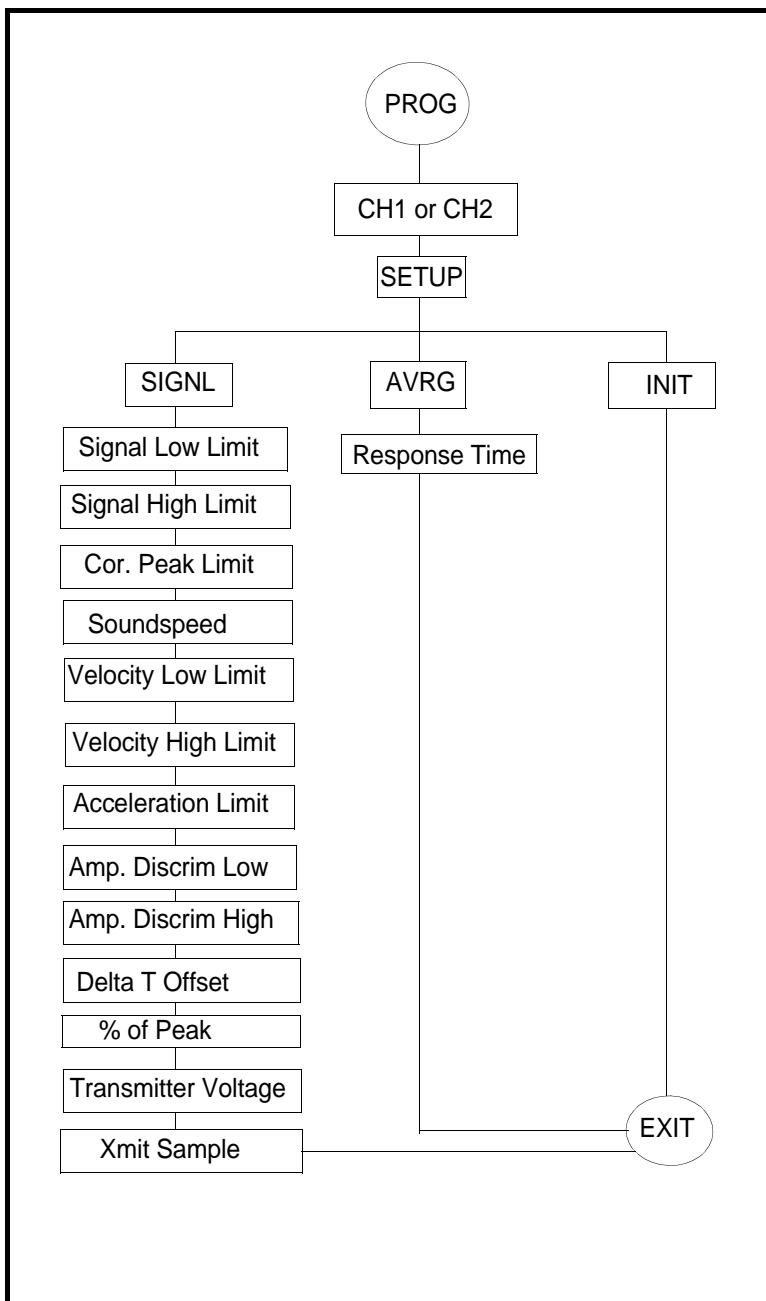
**Figure F-1G: PROG CHANNEL SETUP Options**
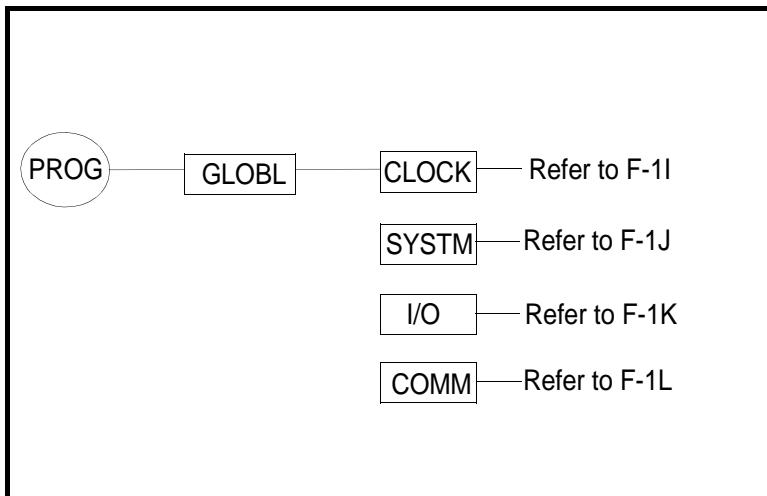
**Figure F-1H:  PROGram Menu GLOBL Options**
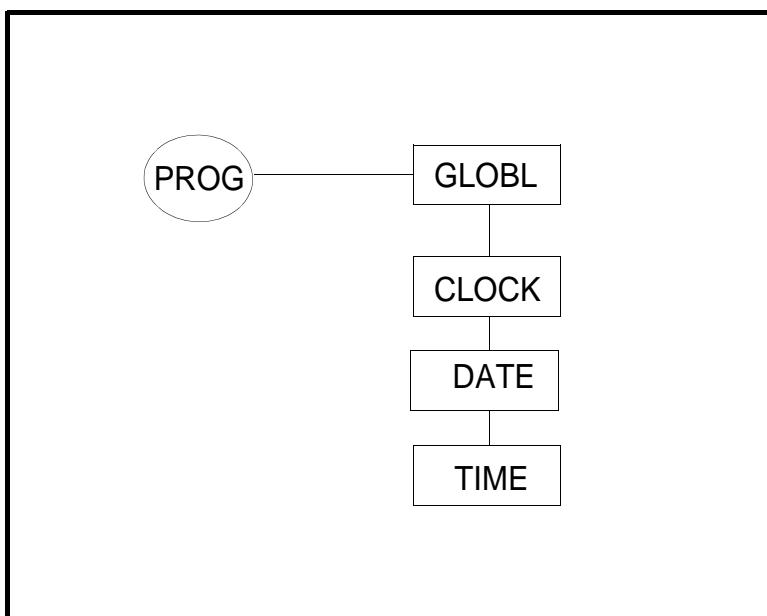


**Figure F-1I:  PROG GLOBL CLOCK Options**

```
┌──────────────────────────────────────────────────┐
│                                                    │
│   ╭──────╮      ┌─────────────┐                    │
│   │ PROG │──────│    GLOBL     │                    │
│   ╰──────╯      └─────────────┘                    │
│                        │                           │
│                 ┌─────────────┐   ┌──────────────┐ │
│                 │    SYSTM     │───│ System Units │ │
│                 └─────────────┘   └──────────────┘ │
│                                          │         │
│                                   ┌──────────────┐ │
│                                   │  Totalizer   │ │
│                                   │   Option     │ │
│                                   └──────────────┘ │
│                                          │         │
│                                   ┌──────────────┐ │
│                                   │Volumetric Units│ │
│                                   └──────────────┘ │
│                                          │         │
│                                   ┌──────────────┐ │
│                                   │ Vol Decimal  │ │
│                                   │    Digits    │ │
│                                   └──────────────┘ │
│                                          │         │
│                                   ┌──────────────┐ │
│                                   │Totalizer Units│ │
│                                   └──────────────┘ │
│                                          │         │
│                                   ┌──────────────┐ │
│                                   │Total Decimal │ │
│                                   │    Digits    │ │
│                                   └──────────────┘ │
│        ┌──────────────┐                            │
│        │    Power     │───── If the Energy         │
│        └──────────────┘      Option is On          │
│               │                                    │
│        ┌──────────────┐                            │
│        │Power Decimal │                            │
│        │   Digits     │                            │
│        └──────────────┘                            │
│               │                                    │
│        ┌──────────────┐                            │
│        │Energy (Total)│                            │
│        └──────────────┘                            │
│               │                                    │
│        ┌──────────────┐                            │
│        │Energy Decimal│                            │
│        │   Digits     │                            │
│        └──────────────┘                            │
│               │                      ╭──────╮      │
│               └──────────────────────│ EXIT │      │
│                                       ╰──────╯      │
│                                                    │
└──────────────────────────────────────────────────┘
```
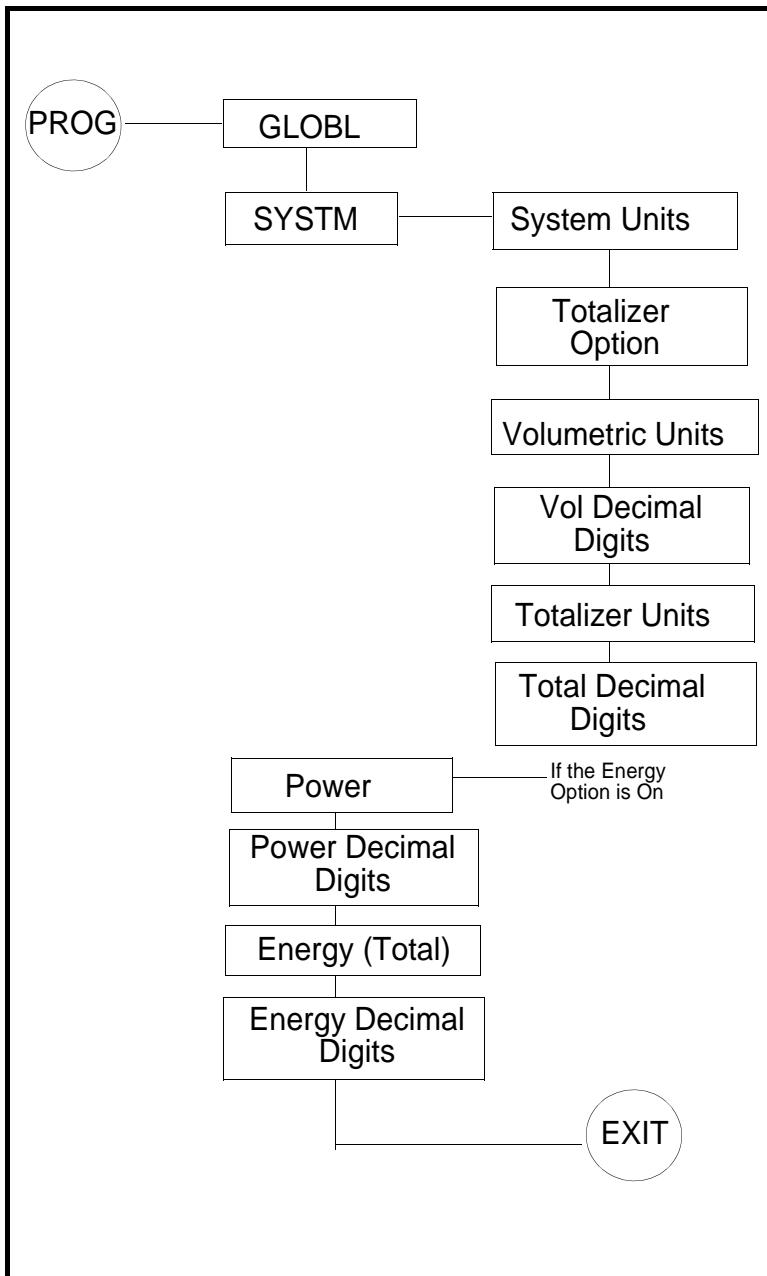
**Figure F-1J:  PROG GLOBL SYSTM Options**
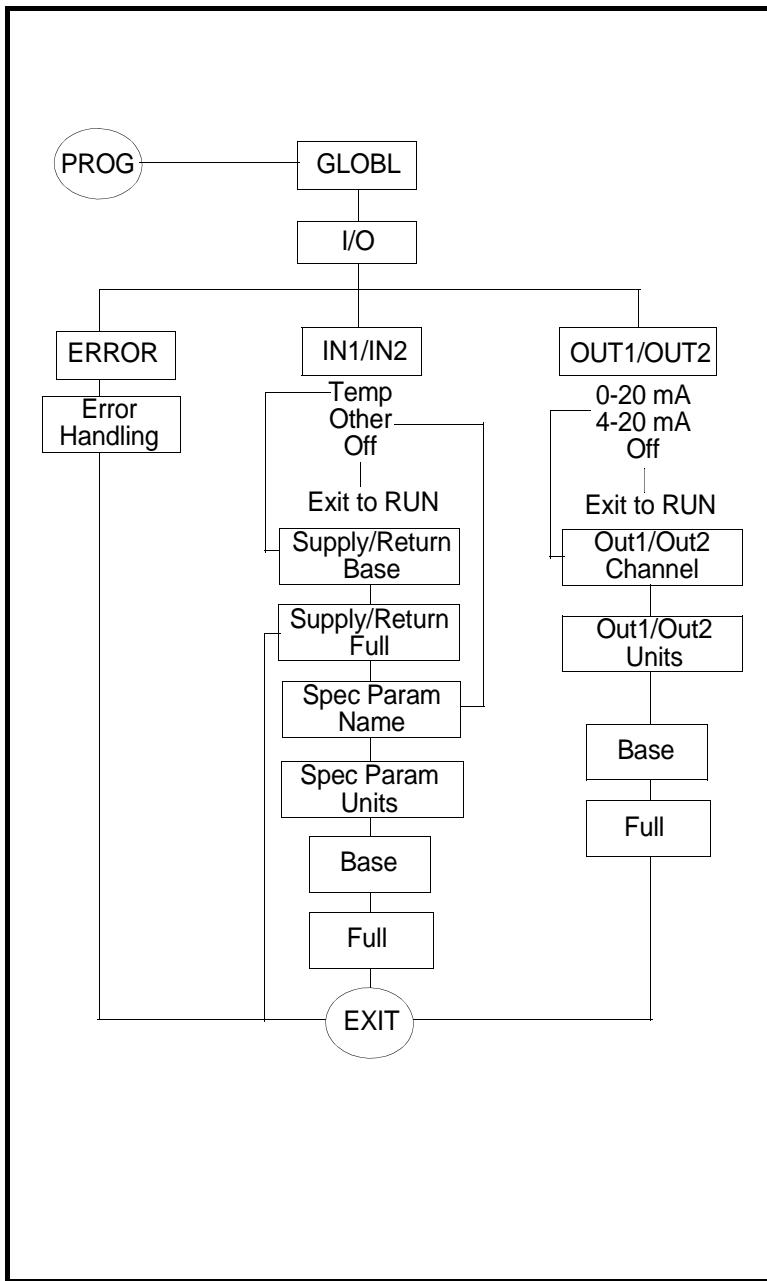
**Figure F-1K: PROG GLOBL I/O Options**
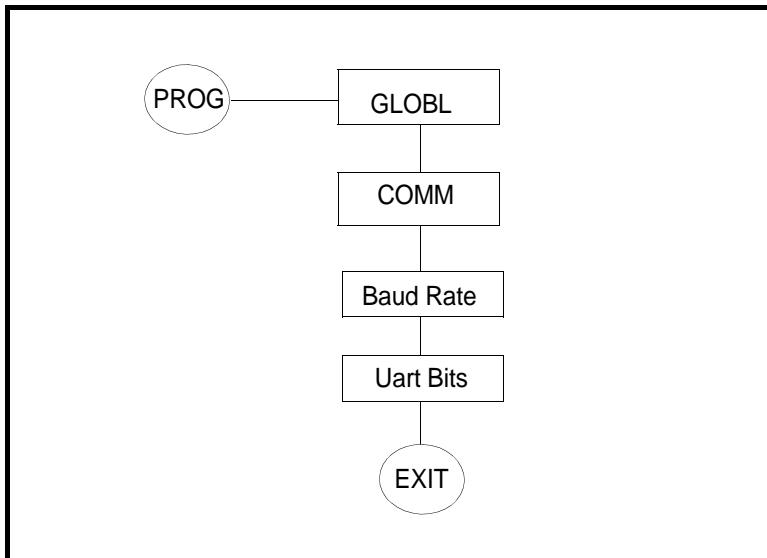
**Figure F-1L:  PROG GLOBL COMM Options**
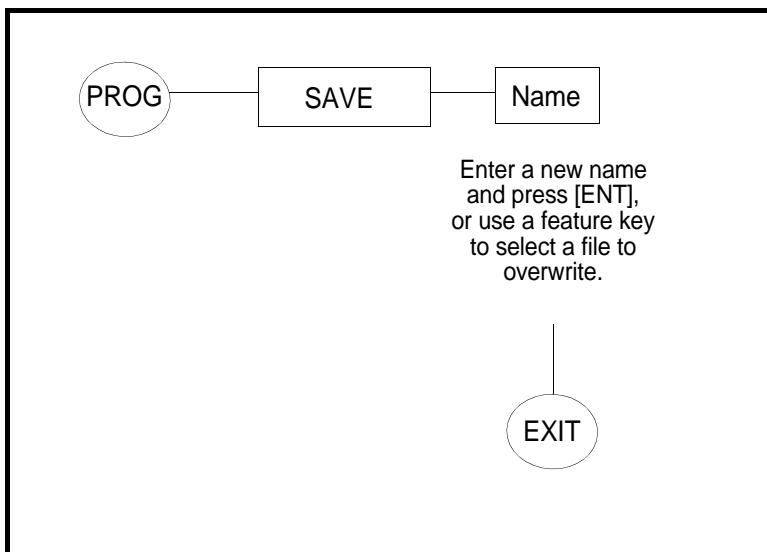


**Figure F-1M:  PROG Menu SAVE Options**
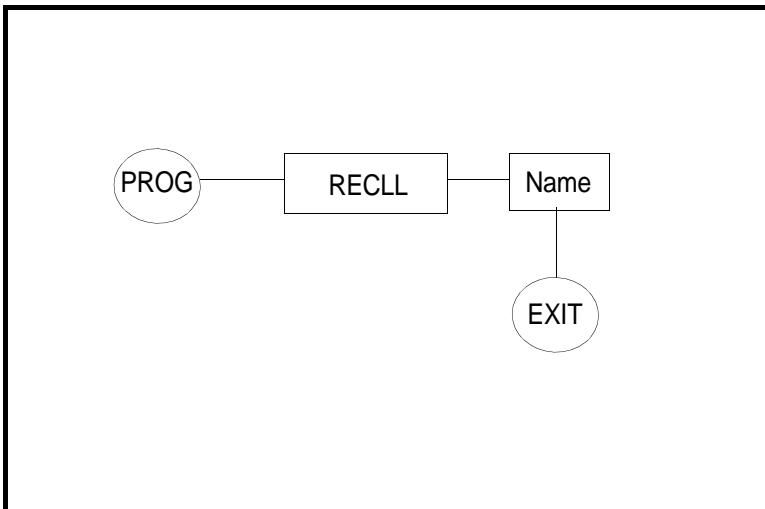
**Figure F-1N: PROG Menu RECLL Options**



**Figure F-2: PRiNT Menu**

PRNT → DATA → Format

Num
or
Plot

1st Value
Printed

Repeats for
each channel
and name.

1st Value
Printed

Select
Channel
and Name

2nd Value
Printed

Repeats for
each channel
and name.

Y Axis Max.

3rd Value
Printed

Repeats for
each channel
and name.

Y Range

Time Increment

Time Increment

The TransPort sends information to
the printer and returns to making
measurements.
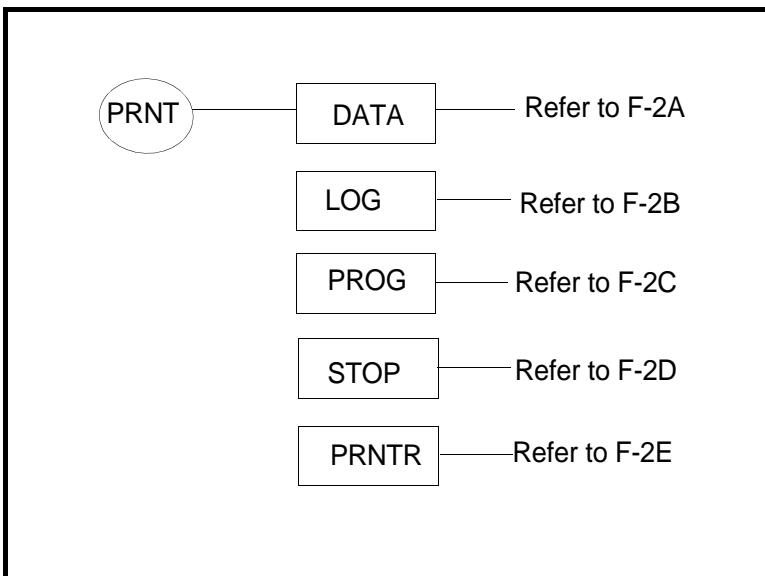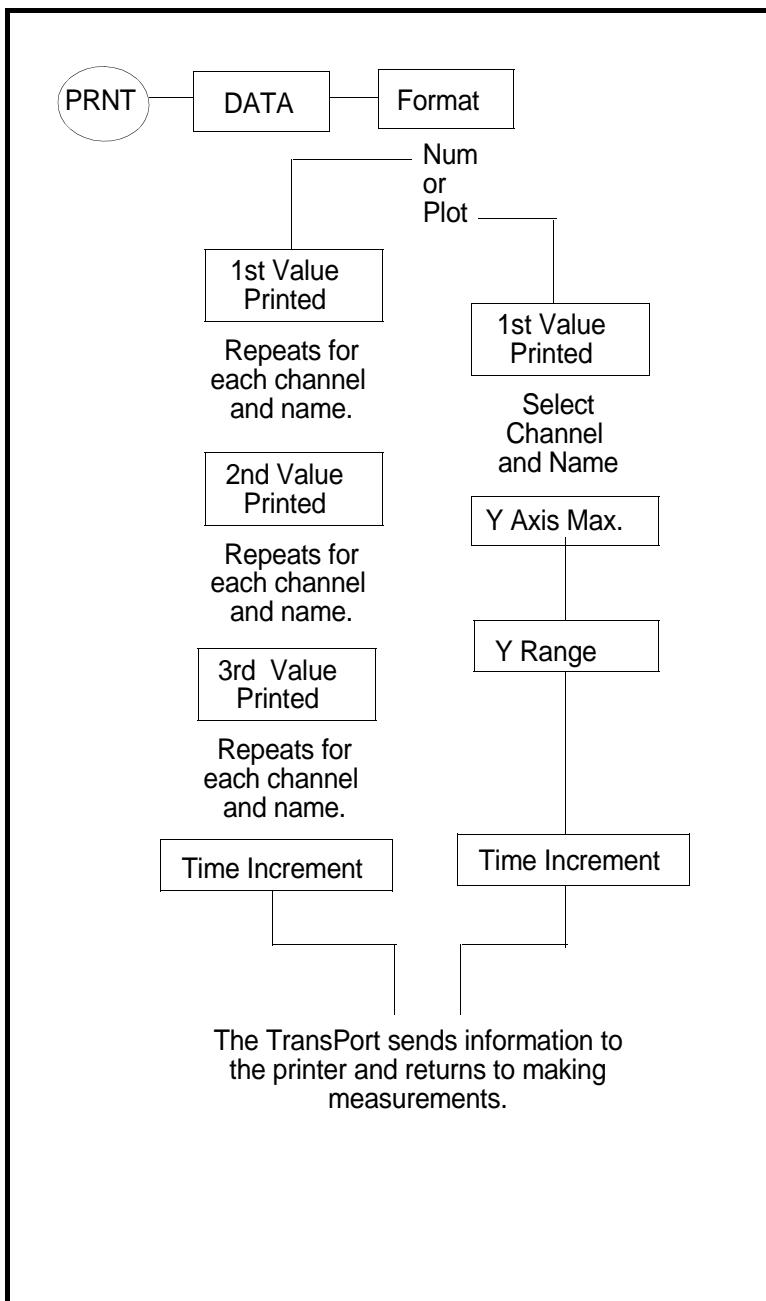
**Figure F-2A: PRiNT Menu DATA Options**

PRNT — LOG — Format

Num
or
Plot

Name

Name

Y Axis Max.

Y Range

The TransPort sends the log to the
printer and returns to making
measurements.
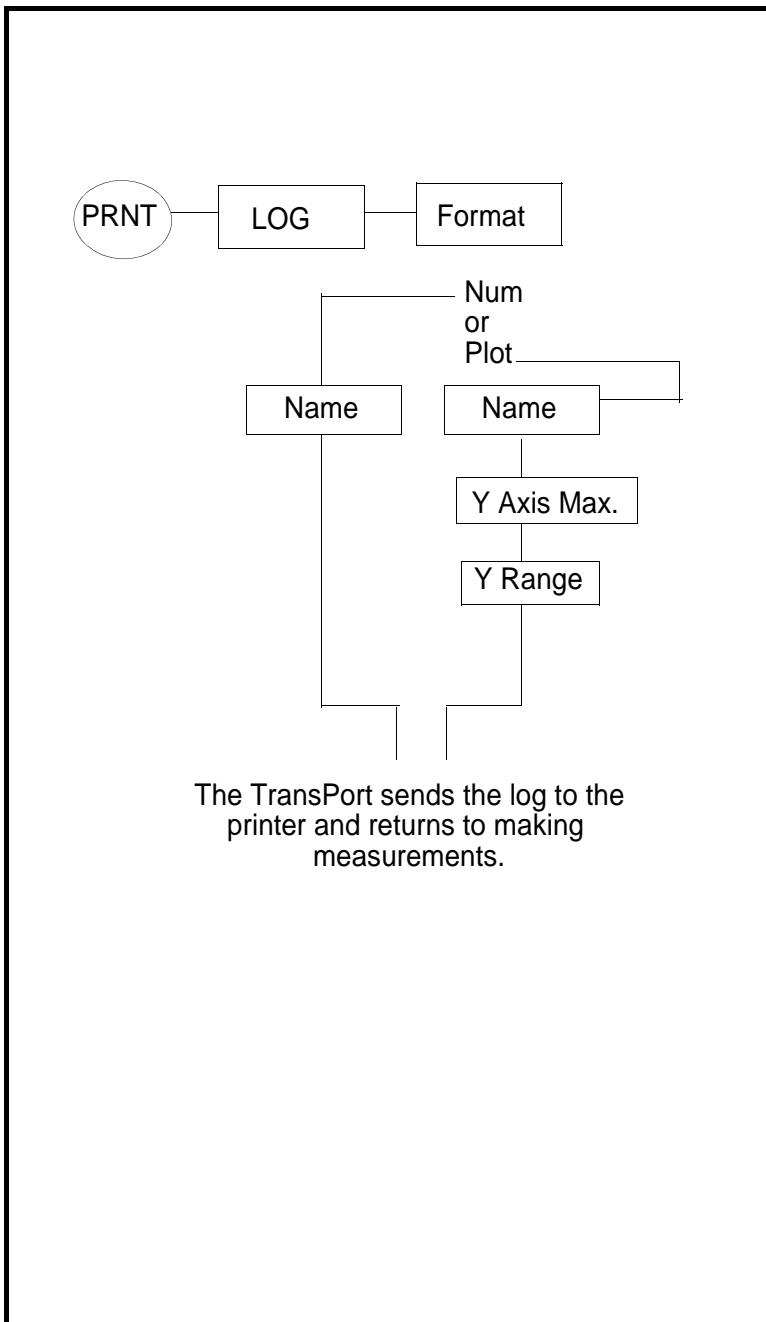
**Figure F-2B: PRiNT Menu LOG Options**
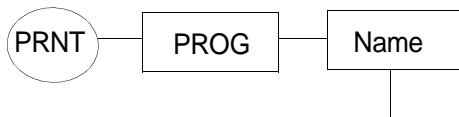
```
  PRNT  ──  PROG  ──  Name
                        │
            The TransPort sends the selected
            channel site file  to the printer and
             returns to making measurements.
```

**Figure F-2C:  PRiNT Menu PROG Options**

PRNT ── STOP ── Stop Printing

No
or
Yes

The TransPort continues printing
the current file and returns to making
measurements.

The TransPort stops printing the
current file and returns to making
measurements.
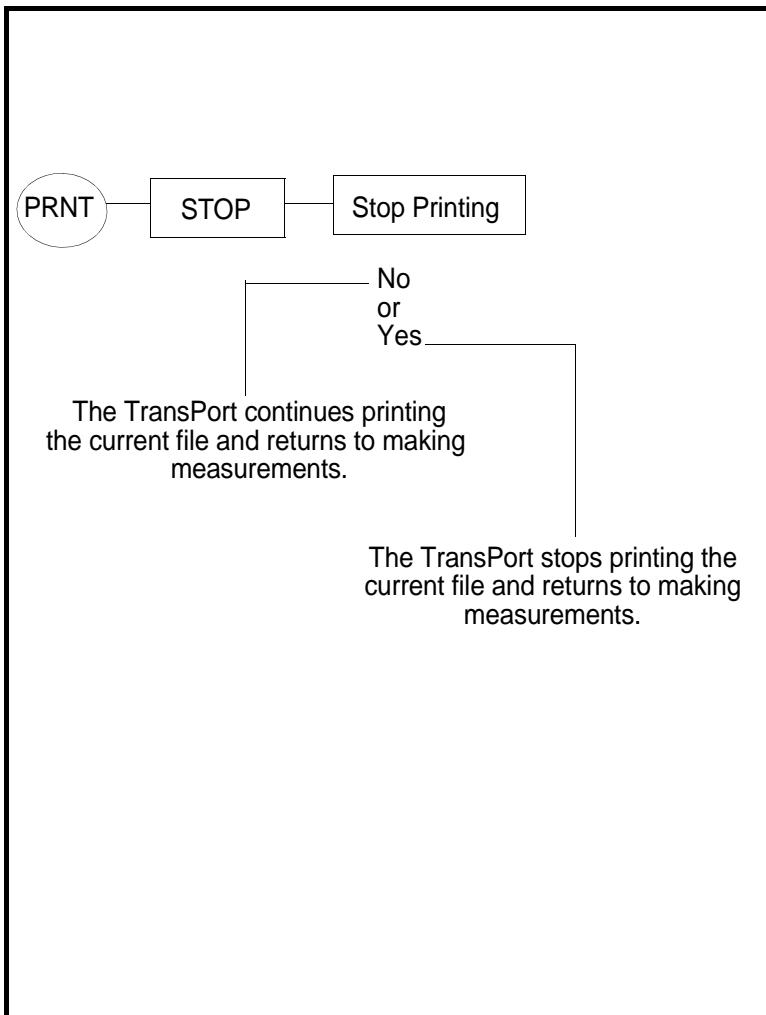
**Figure F-2D:  PRiNT Menu STOP Options**

PRNT ─── PRNTR ─── Printer Type

The TransPort returns to making measurements.
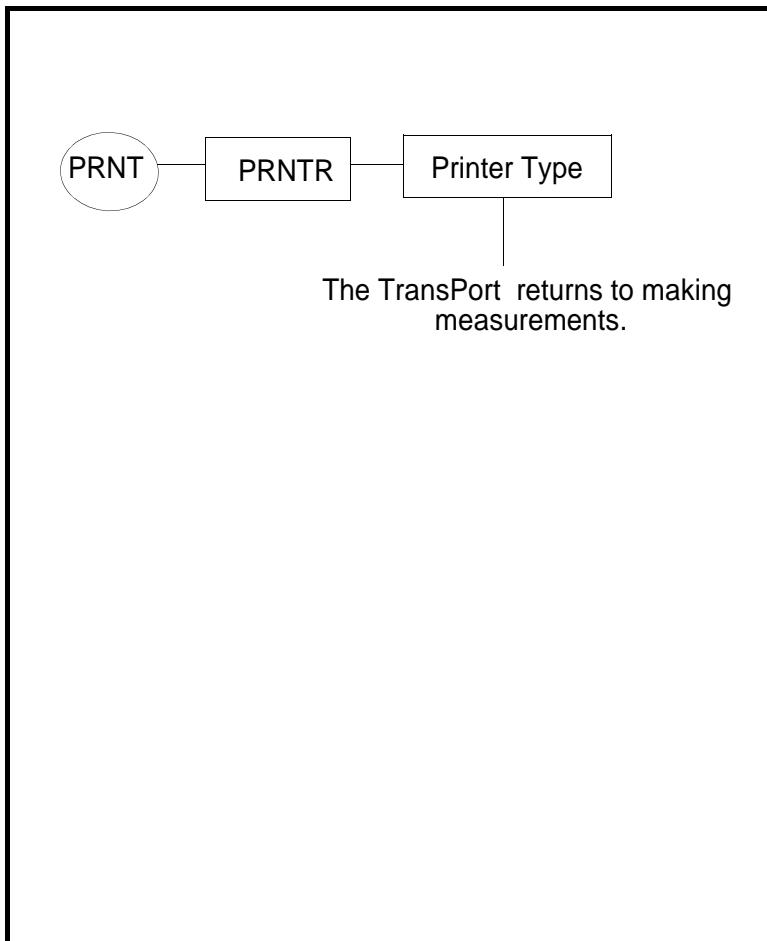
**Figure F-2E: PRiNT Menu PRiNTeR Options**

```
        ( LOG )——— Log Menu
           │
     ┌─────┼─────────────────┐
  ┌──────┐    ┌─────┐     ┌──────┐
  │PARAM │    │ MEM │     │ STOP │
  └──────┘    └─────┘     └──────┘
     │     X/X Pages FREE     │
  ┌──────┐ X Pages PENDING ┌──────┐
  │ Name │                 │ Name │
  └──────┘  Press [ENT]    └──────┘
     │                        │
┌───────────┐          ┌─────────────┐
│Log Message│          │Stop Logging │
└───────────┘          └─────────────┘
┌───────────┐              No
│ 1st Value │              or
│  Logged   │              Yes
└───────────┘
┌───────────┐           The
│ 2nd Value │           TransPort
│  Logged   │           continues
└───────────┘           logging.
┌───────────┐
│ 3rd Value │               The
│  Logged   │               TransPort
└───────────┘               stops logging
If Totals are ┌──────────┐  the selected
 selected     │Set Log   │  file.
              │Totals to?│
              └──────────┘
┌───────────┐
│Start Time │
└───────────┘
┌───────────┐
│Start Date │
└───────────┘
┌───────────┐
│ End Time  │
└───────────┘
┌───────────┐
│ End Date  │
└───────────┘
┌────────────────┐
│Time Increment  │
└────────────────┘
                         ( EXIT )
```

**Figure F-3:  LOG Menu**

**Figure F-4: DISPlay Menu**

CLR — Clear Menu

TOTAL

Total to Clear

No
or
Yes

The TransPort clears the totals and returns to making measurements.

The TransPort returns to making measurements.

SITE

Name

Clear Site?

No
or
Yes

The TransPort clears the selected channel.

EXIT

LOG

Name

Clear Log

No
or
Yes

The TransPort clears the log and returns to making measurements.
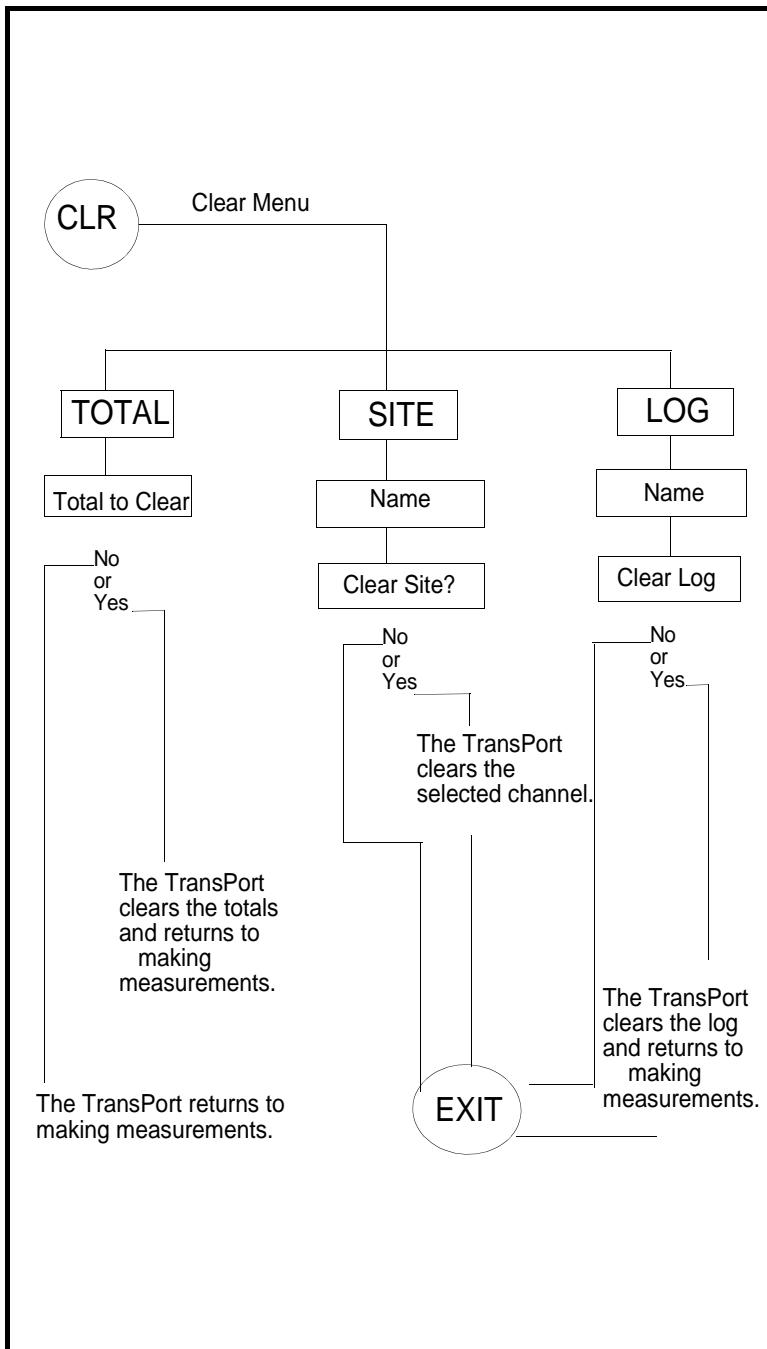
**Figure F-5: CLeaR Menu**
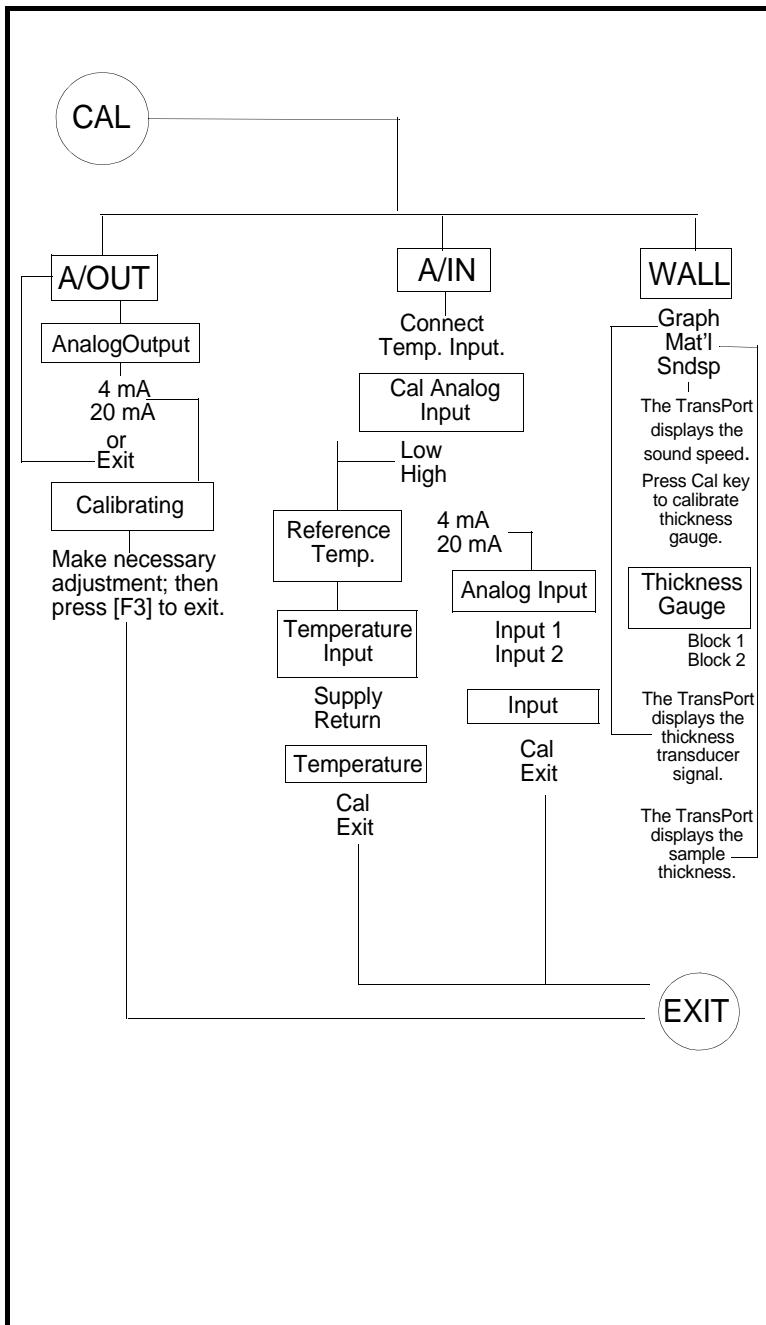
**Figure F-6: CALibration Menu**
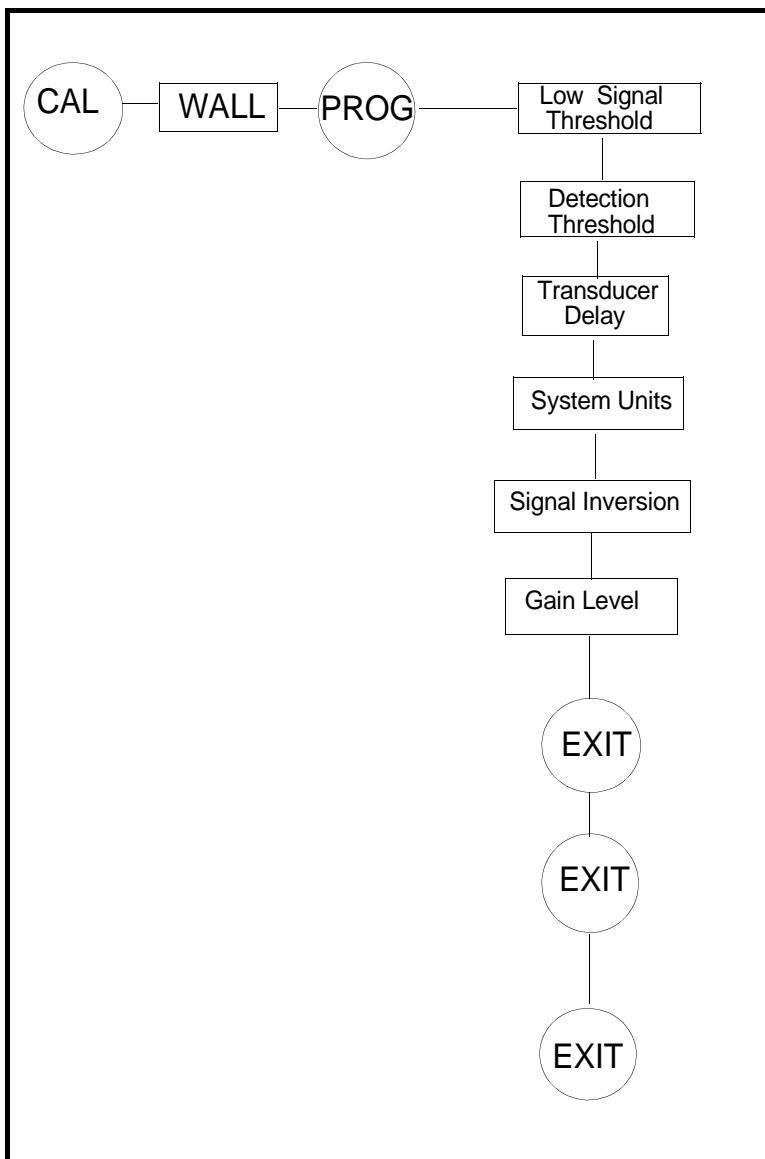
**Figure F-7:  Ultrasonic Thickness Gauge PROG**

# Appendix G
# Ultrasonic Thickness Gauge Theory of Operation

All ultrasonic thickness gauging involves timing the round trip of a sound pulse in a test material. Because solid metal has an acoustic impedance that differs from that of gases, liquids, or corrosion products such as scale or rust, the sound pulse will reflect from the far surface of the remaining metal. The test instrument is programmed with the velocity of sound in the test material, and computes the wall thickness from the simple formula

$$\text{Distance} = \text{Velocity} \times \text{Time}$$

Single element transducers use one element as both transmitter and receiver. Dual element transducers incorporate separate transmitting and receiving elements. These elements are mounted on delay lines that are usually cut at an angle to the horizontal plane (the roof angle), so that the transmitting and receiving beam paths cross beneath the surface of the test piece. This crossed-beam design of duals provides a pseudo-focussing effect that optimizes measurement of minimum wall thickness in corrosion applications. Duals will be more sensitive than single element transducers to echoes from the base of pits that represent minimum remaining wall thickness. Also, duals may often be used more effectively on rough outside surfaces. Couplant trapped in pockets on rough sound entry surfaces can produce long, ringing interface echoes that interfere with the near surface resolution of single element transducers. With a dual, the receiver element is unlikely to pick up this false echo. Finally, duals may be designed for high temperature measurements that would damage single element contact transducers.

# Factors Affecting Performance and Accuracy

**A. Surface Condition** — Loose or flaking scale, rust, corrosion or dirt on the outside surface of a test piece will interfere with the coupling of sound energy from the transducer into the test material. Thus, any loose debris of this sort should be cleaned from the specimen with a wire brush or file before measurements are attempted. Generally it is possible to make corrosion measurements through thin layers of rust, as long as the rust is smooth and well bonded to the metal below. Some very rough cast or corroded surfaces may have to be filed or sanded smooth in order to insure proper sound coupling. It may also be necessary to remove paint if it has been applied in thick coats, or if it is flaking off the metal. While it is often possible to make corrosion measurements through thin coats of paint (on the order of a few thousandths of an inch or 0.1 - 0.2 mm), thick paint will attenuate signals or possibly create false echoes, causing inaccurate measurements.

Severe pitting on the outside surface of a pipe or tank can be a problem. On some rough surfaces, the use of a gel or grease rather than a liquid couplant will help transmit sound energy into the test piece. In extreme cases it will be necessary to file or grind the surface sufficiently flat to permit contact with the face of the transducer. In applications where deep pitting occurs on the outside of a pipe or tank it is usually necessary to measure remaining metal thickness from the base of the pits to the inside wall. There are sophisticated ultrasonic techniques utilizing focussed immersion transducers that can measure directly from the base of the pit to the inside wall, but this is generally not practical for field work. The conventional technique is to measure unpitted metal thickness ultrasonically, measure pit depth mechanically, and subtract the pit depth from the measured wall thickness. Alternately, one can file or grind the surface down to the base of the pits and measure normally.

# Factors Affecting Performance and Accuracy (cont.)

As with any difficult application, experimentation with actual product samples is the best way to determine the limits of a particular gage/transducer combination on a given surface.

**B. Transducer Positioning/Alignment** — For proper sound coupling the transducer must be pressed firmly against the test surface. On small diameter cylindrical surfaces such as pipes, hold the transducer so that the sound barrier material visible on the probe face is aligned perpendicular to the center axis of the pipe. See Figure G-1 below.
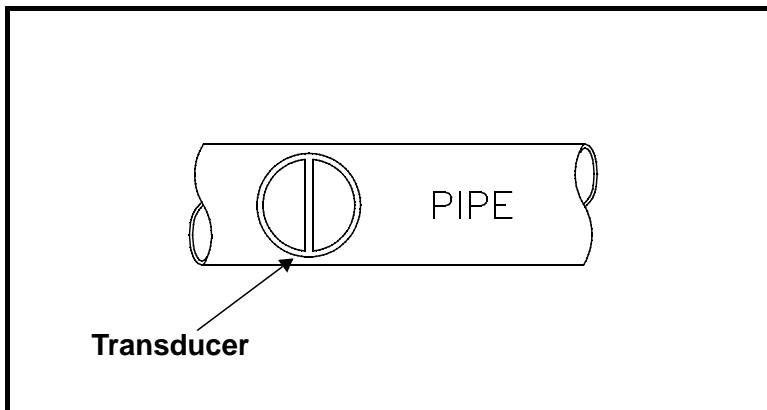


**Figure G-1: Proper Alignment of Transducers for Cylindrical Surfaces**

While firm hand pressure on the transducer is necessary for good readings, the probe should never be scraped along or twisted against a rough metal surface. This will scratch the face of the transducer and eventually degrade performance. The safest technique for moving a transducer along a rough surface is to pick it up and reposition it for each measurement, not to slide it along.

# Factors Affecting Performance and Accuracy (cont.)

Remember that an ultrasonic test measures thickness at only one point within the beam of the transducer, and that in corrosion situations wall thicknesses often vary considerably. Test procedures usually call for making a number of measurements within a defined area and establishing a minimum and/or average thickness. Ideally, data should be taken at increments no greater than half the diameter of the transducer, to insure that no pits or other local variations in wall thickness are missed. It is up to the user to define a pattern of data collection appropriate to the needs of a given application.

It is possible that on some severely corroded or pitted materials there will be spots where readings cannot be obtained. This can happen when the inside surface of the material is so irregular that the sound energy is scattered rather than being reflected back to the transducer. The lack of a reading may also indicate a thickness outside the range of the transducer and instrument being used. Generally, an inability to obtain a valid thickness reading at a particular point on a test specimen could be a sign of a seriously degraded wall which may warrant investigation by other means.

C. **Calibration** — The accuracy of measurements are only as good as the accuracy and care with which the gage has been calibrated. There are no internal calibration adjustments in the TransPort. However, it is essential that the velocity and zero calibrations described in Chapter 9, *Using the Ultrasonic Thickness Gauge*, be performed whenever the transducer is changed or you have a reason to doubt the accuracy of the readings. Periodic checks with samples of known thicknesses are recommended to verify that the gage is operating properly.

# Factors Affecting Performance and Accuracy (cont.)

**D. Taper or Eccentricity** — If the contact surface and the back surface are tapered or eccentric with respect to each other, the return echo again becomes distorted and the accuracy of measurement is diminished.

**E. Acoustic Properties of the Material** — There are several conditions found in engineering materials that can severely limit the accuracy and thickness range that can be measured.

**1.** Sound Scattering
In some materials, notably certain types of cast stainless steel, cast irons, and composites, the sound energy is scattered from individual crystallites in the casting or from dissimilar materials within the composite. This effect reduces the ability to discriminate a valid return echo from the back side of the material and limits the ability to gauge the material ultrasonically.

**2.** Velocity Variations
A number of materials exhibit significant variations in sound velocity from point-to-point within the material. Certain types of cast stainless steels and brass exhibit this effect due to a relatively large grain size and the anisotropy of sound velocity with respect to grain orientation. Other materials show a rapid change in sound velocity with temperature. This is characteristic of plastic materials where temperature must be controlled in order to obtain maximum precision in the measurement.

**3.** Sound Attenuation or Absorption
In many organic materials, such as low density plastics and rubber, sound is attenuated very rapidly at the frequencies used in normal ultrasonic thickness gauging. Therefore, the maximum thickness that can be measured in these materials is often limited by sound attenuation.

# Appendix H
# Screen and Error Messages

This appendix contains the common screen and error messages that may appear on the TransPort screen either while the unit is making measurements or while you are performing a task. The table below lists the messages alphabetically. If the message begins with a number, use the second word in the message when looking it up. Symbols are listed first in the table in random order.

| Message | Description/Action |
|---------|--------------------|
| * | Indicates the TransPort is logging data. |
| → | Indicates that there are more menu options available. Use the [←] and [→] keys to view the options. |
| All Logs Cleared! hit key | This message may appear while performing the following:<br>• clearing a log - there are no more logs to delete;<br>• logging data - user has hit [ENT] instead of selecting an old log, or entering a new name;<br>• printing a log - there are no logs to print;<br>•displaying a log - there are no logs to display.<br>Hit any key and the TransPort returns to making measurements. |

| Message | Description/Action |
|---|---|
| All Sites Cleared! hit key | This message may appear while performing the following:<br>•saving a new site - the user did not enter a new name or select to overwrite an existing site;<br>•recalling a site - there are no site files to recall;<br>•clearing a site - there are no sites to delete;<br>•printing a site - there are no sites to print;<br>•displaying a site - there are no sites to display.<br>Hit any key and the TransPort returns to making measurements. |
| Backup Battery FAIL | This message appears at power up. This message indicates the backup battery, which stores the non-volatile RAM, has failed. Contact the factory. |
| Backup Battery OK | This message appears at power up. This message indicates the backup battery, which stores the non-volatile RAM, has passed. |
| Do you want to SAVE? | This message appears when you try to exit the PROGram Menu without saving the new site parameters. Use the appropriate function key to respond. If you choose not to save the new site parameters, the TransPort will keep the newly entered parameters in RAM. The new parameters will be lost the next time you recall or change parameters. |
| E0: No Error | This message appears on the message line on the screen. This indicates there is no error (may appear briefly after another error message). See page 10-3 for more information. |

*Screen and Error Messages*

| Message | Description/Action |
|---|---|
| E1: Low Signal | This message appears on the message line on the screen. This indicates that the ultrasonic signal is poor and exceeds the limits programmed in the PROGram Menu SETUP option. Check the transducer as described on page 10-11. |
| E2: Sound Speed Error | This message appears on the message line on the screen. This indicates that the sound speed for your fluid exceeds the limits programmed in the PROGram Menu SETUP option. Refer to Appendix B to look up the sound speed. Also, refer to page 10-3. |
| E3: Velocity Range | This message appears on the message line on the screen. The velocity exceeds the programmed limits (velocity limits are programmed using the PROGram Menu SETUP option). Refer to page 10-3. |
| E4: Signal Quality | This message appears on the message line on the screen. This indicates the signal quality exceeds the limits programmed in the PROGram Menu SETUP option. Check transducer and couplant as described on page 10-11. Relocate transducers if possible. Also, refer to page 10-4 for more information. |
| E5: Amplitude Error | This message appears on the message line on the screen. This indicates the amplitude exceeds the limits programmed in the PROGram Menu SETUP option. Refer to page 10-4. |
| E6: Cycle Skip, Accel | This message appears on the message line on the screen. This indicates that the acceleration exceeds the limits programmed in the PROGram Menu SETUP option. Refer to page 10-4. |

| Message | Description/Action |
|---|---|
| E7: Analog Out Error | This message appears on the message line on the screen. Current or voltage is over the limit. Refer to page 10-4. |
| E8: TEMPerature INput SUPPLY/IN1 | This message appears on the message line on the screen. Supply temperature input is out of range. Check cable and transmitter. Also, refer to page 10-4. |
| E9: TEMPerature INput RETURN/IN2 | This message appears on the message line on the screen. Return temperature input is out of range. Check cable and transmitter. Also, refer to page 10-4. |
| End Time must exceed Start Time by 5 min. | This message appears when in the LOG Menu. Enter an end time that is at least 5 minutes later than the start time. |
| EPROM sum = XXXX | This message appears at power-up. It is a good idea to record the EPROM sum periodically just in case problems arise. We recommend that you record the EPROM sum the first time you power up the TransPort. |
| FRIGID_INIT Executed | The NVR was automatically initialized due to memory fault. Consult the factory. |
| Illegal Pipe C Enter Bulk C | This message appears while in the PROGram Menu PIPE option. Pipe wall will not support Rayleigh wave transducers. Enter the pipe sound speed. |
| Log Active, END only hit any key | This message appears when in the LOG Menu. This indicates the Log is still compiling data. You may only edit the End Time. |
| Log DONE, to inspect hit any key | This message appears when in the LOG Menu. This indicates the Log is complete. Hit any key and the TransPort displays the log on the screen. |

| Message | Description/Action |
|---|---|
| Low Signal | This message appears while using the thickness gage. This indicates the input device signal is poor. |
| NVR FAIL | This message appears at power up. This message indicates that the non-volatile RAM has failed. Contact the factory. |
| NVR O.K. | This message appears at power up. This message indicates that the non-volatile RAM has passed. |
| Outside limits, value rejected. | This message appears when in the CAL Menu. This message indicates that the calibration for the analog output is invalid. Hit any key to clear this message. The TransPort defaults to the last valid calibration for the analog output. This message also appears if you do not have an ammeter or a multimeter connected to the TransPort while trying to calibrate the analog output. |
| __ range is X.XX to X.XX | This message appears while in the PROGram Menu. This indicates the entered number is unacceptable. Hit any key and enter a number within range. |
| S | This message appears in the indicator box. S indicates the shift key function is activated. Press a key or the shift key twice to deactivate the shift function. |
| $S_L$ | This message appears in the indicator box. $S_L$ indicates the shift key function is locked. Press the shift key to unlock. |

| Message | Description/Action |
|---|---|
| Start | This message appears in the indicator box. This message appears frequently when performing all tasks. Start indicates that you are at the beginning of a task menu or option. |
| Starting time must exceed current time! | This message appears while in the LOG menu PARAM option. This message indicates that the programmed start time for the log is earlier than the current time. Enter a later time. |

# Appendix I

# Uploading Logs
# to a Personal Computer

You can upload logs from your 2PT868 to a personal computer (PC) using the Windows® Terminal Function. To upload logs, you need to do the following:

- Connect the 2PT868 to a PC

- Check the 2PT868 Baud Rate Setting

- Set Up Windows® Terminal Function

- Transfer Log(s) to the PC

## Checking the Baud Rate

In order to make sure your computer and flowmeter are communicating at the same speed, you should check the 2PT868 baud rate setting as follows:

**1.** Press [PROG].

**2.** Press [→] and [F2] to select *COMM*.

**3.** The 2PT868 will display the baud rate. Note the settings and press [EXIT] twice.

## Setting Up Windows Terminal Function

**1.** In Windows®, select the Terminal Function. The Terminal Function is usually located in the Accessories window.

**2.** The Terminal Screen appears with six menus at the top of the screen. Using the Settings Menu, select the Communications Option.

## Setting Up Windows Terminal Function (cont.)

**3.** The Communications Screen appears. Make the following selections:

- Baud Rate - select the same baud rate the 2PT868 is using (from *Checking the Baud Rate,* above)

- Data Bits - 8

- Stop Bits - 1

- Parity - None

- Flow Control - Xon/Xoff

- Connector - select the correct communications port.

- Make sure Parity Check and Carrier Detect are <u>not</u> checked.

**4.** Using the Transfer Menu, select the Receive Text File Option.

**5.** A window appears asking you to enter a file name. Select the desired directory and file name (with .prt extension) and then click on OK.

### Transferring Logs to the PC

Using the 2PT868 keypad, press the following keys:

**1.** [PRNT] to enter the Print Menu.

**2.** [F2] to select *LOG.*

**3.** [F1] to select *NUM*.

**4.** Press the appropriate function key to select the desired log to upload.

The PC will start uploading the log. When the log is completely uploaded, you can import the file into any commercial spreadsheet.

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## DECLARATION OF CONFORMITY

**PANAMETRICS**

We,

**Panametrics Limited**

**Shannon Industrial Estate**

**Shannon, Co, Clare**

**Ireland**

declare under our sole responsibility that the

**2PT868 Ultrasonic Flowmeter**

to which this declaration relates is in conformity with the following standards:

• EN 61326:1998, Class A, Annex A, Continuous Unmonitored Operation
• EN61010-1:1993 + A2:1995, Overvoltage Category II, Pollution Degree 2

following the provisions of 89/336/EEC EMC Directive and 73/23/EEC Low Voltage Directive.

Shannon - August 1, 2001

Mr. James Gibson
GENERAL MANAGER

$C\epsilon$

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Shannon

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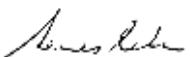
PANAMETRICS

Nous,                              **Panametrics Limited**
**Shannon Industrial Estate**
**Shannon, Co, Clare**
**Ireland**

déclarons sous notre propre responsabilité que le

**2PT868 Ultrasonic Flowmeter**

rélatif á cette déclaration est en conformité avec les documents suivants:

• EN 61326:1998, Class A, Annex A, Continuous Unmonitored Operation
• EN61010-1:1993 + A2:1995, Overvoltage Category II, Pollution Degree 2

suivant les régles de la Directive de Compatibilité Electromagnétique
89/336/EEC et de la Directive Basse Tension 73/23/EEC.

Shannon - August 1, 2001

Mr. James Gibson
GENERAL MANAGER

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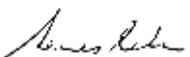
**PANAMETRICS**

Wir,
**Panametrics Limited**
**Shannon Industrial Estate**
**Shannon, Co, Clare**
**Ireland**

erklären, in alleiniger Verantwortung, daß das Produkt

**2PT868 Ultrasonic Flowmeter**

folgende Normen erfüllt:

• EN 61326:1998, Class A, Annex A, Continuous Unmonitored Operation
• EN61010-1:1993 + A2:1995, Overvoltage Category II, Pollution Degree 2

gemäß den Europäischen Richtlinien, Niederspannungsrichtlinie
Nr.: 73/23/EWG und EMV-Richtlinie Nr.: 89/336/EWG.

Shannon - August 1, 2001

Mr. James Gibson
GENERAL MANAGER

$C \epsilon$

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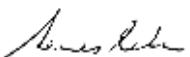
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